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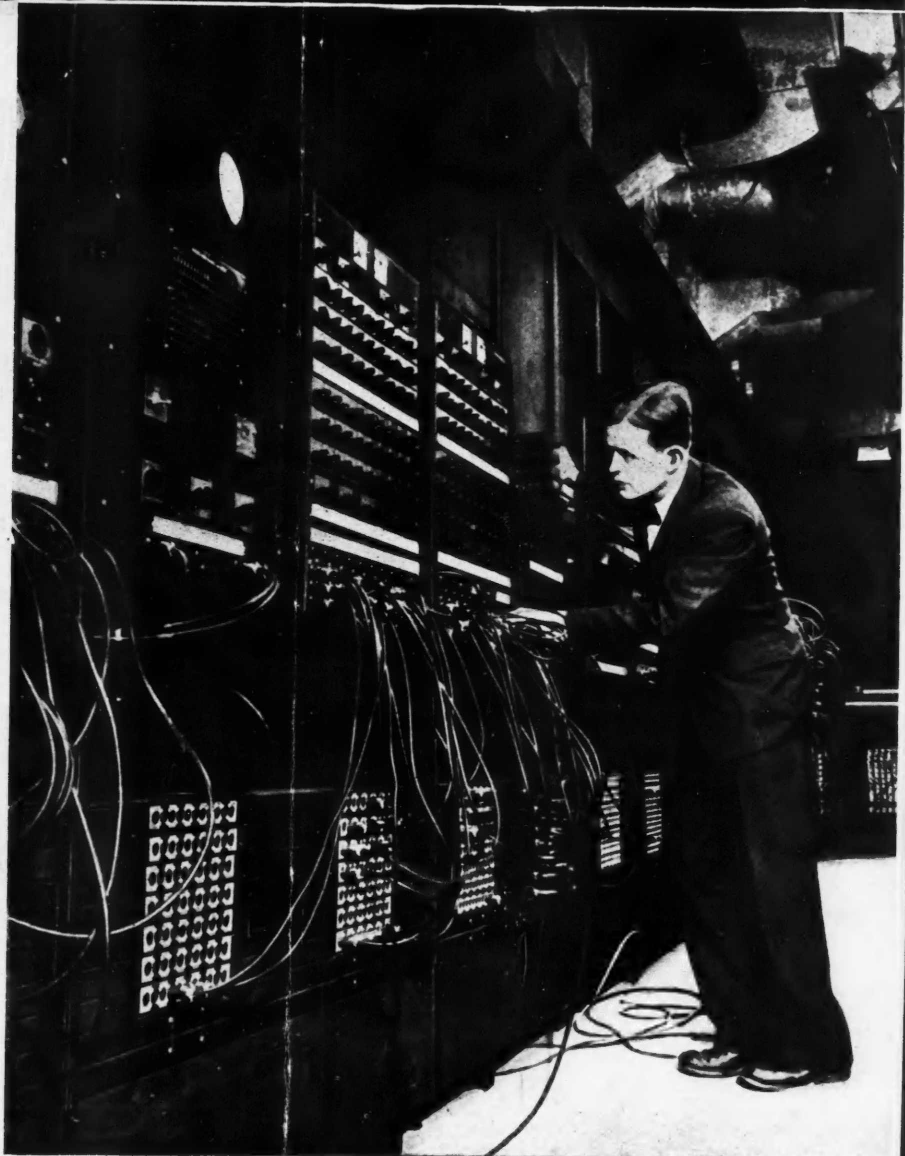

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MAURICE GOLDSMITH,
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THE MAGAZINE OF SCIENTIFIC PROGRESS

January, 1947 Vol. VIII. No. 1

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The Progress of Science

Next Stop: Mexico City

ONE of the most encouraging events of 1946 was the first annual conference of the United Nations Educational, Scientific and Cultural Organisation, a specialised agency of the United Nations which is second to none in potential importance. At that conference *UNESCO*'s real existence began. The solving of most problems, not least of which is the maintenance of world peace, brings one back to the subject of education, which is *UNESCO*'s primary concern. In the collection of initials that make up the name *UNESCO* the letter 'E' is the key letter, a point which is brought home forcibly by those who argue that if *UNESCO* is concerned with Education in the widest sense then the 'S' and the 'C' are somewhat superfluous.

Out of the forty-four nations which drew up *UNESCO*'s charter, twenty-eight[1] had ratified its constitution and could thus exercise a vote at the Paris conference which concluded on December 10. Here the abstention of Russia cannot be overlooked. The U.S.S.R., which participated in the drafting of *UNESCO*'s constitution, sent no delegation to Paris, and the disappointment which everyone at the conference felt and which was expressed by many delegates would scarcely have been softened had an official observer been sent. As Dr. Huxley said: "It will clearly be impossible to establish *UNESCO* as a truly global agency if one of the most powerful and most culturally advanced states, controlling one twelfth of the world's population, is not a member." Russia has given at the time of writing no reason for her abstention. Perhaps Yugoslavia, which sent official observers though she had not ratified the constitution and therefore could not vote, gave a clue to it when one of her delegates expressed the fear that a centralised cultural body might damage the thought and spirit of creation in individual countries and arbitrarily impede the development of national culture. But as this remark came after Dr. Huxley had been presenting his creed of scientific humanism as a possible creed for *UNESCO* to adopt, an exposition that involved a reference to Marxism which some people resented, the Yugoslav words can perhaps be taken too seriously. Perhaps the reason for Russia's absence was that suggested by Archibald MacLeish of the U.S. delegation when he said, "They simply want to see how *UNESCO* shapes."

Among the conference's last acts were the decision to meet next year in Mexico City and the election of a Director-General. Their choice was Dr. Julian Huxley, who has seen the agency through its embryonic stage as a preparatory commission and who directed the drawing up of the programmes to which the conference devoted detailed study. From the beginning he was a firm favourite for the permanent position. *UNESCO* has certainly done well to obtain so enthusiastic and energetic a director as Dr. Huxley, who has the breadth of interest which is essential in the head of an organisation with so big and ambitious a programme. No one will covet him a penny of his large tax-free salary for, as J. B. Priestley put it, the post "is so loaded with responsibilities and bristling with worries that it will probably soon wear out any man old enough to be suitable for it. In Paris they are saying that the only man fit to be Director-General of *UNESCO* was Leonardo da Vinci, and that he was not a sufficiently good administrator."

Some eyebrows have been raised at the size of *UNESCO* salaries. They are certainly high, but no higher than they have to be if *UNESCO* is to recruit the best staff. The experience of other international bodies has proved this. Another factor to be reckoned with when judging *UNESCO* salaries is the fact that in official circles snobbery takes the form of estimating a man's prestige by the size of his salary. Deplorable though this is, it cannot be ignored.

UNESCO has a quite sizable budget. After paying back the British and French Governments who looked after the embryonic organisation financially at a time when it had no income of its own, *UNESCO* has six

[1] The following are the twenty-eight nations: Australia, Belgium, Brazil, Britain, Canada, China, Czechoslovakia, Egypt, France, Greece, Holland, India, Mexico, Norway, Poland, Turkey, the United States, Venezuela, Bolivia, Dominican Republic, Lebanon, New Zealand, Peru, Phillipines, South Africa, Syria. The first eighteen countries in this list are represented on the Executive Board of *UNESCO* by one delegate each; the British delegate on the Board is Sir John Maud, permanent secretary to the Ministry of Education.

million dollars left to cover its activities during 1947, apart from a supplementary sum of 400,000 dollars that is being allocated for its activities in connexion with relief and rehabilitation. Measures of relief and rehabilitation are not to be a charge on *UNESCO* funds, and the organisation will concentrate on planning and advising on such matters; the actual cost of implementing the measures decided upon are to be borne by some other agency, presumably the Social and Economic Council of *UNO*. With six million dollars *UNESCO* will be able to make a really effective start on its programme, a start impressive enough to convince the supporting nations that the money they are contributing has been well spent and that the *UNESCO* venture is more than worth while. Some there are who argue that more liberal funds at this stage might carry disadvantages, in that some of the most ambitious and least practical schemes would be attempted at a time when *UNESCO* has the staff only to deal with essential things and according to a strict system of priorities. There is a good deal that justifies this argument.

To *UNESCO*'s programme we have devoted space in the last issue, and elsewhere in this issue. Some of its plans, one recognises, have clearly been inspired by a fine sense of reality. There are others that seem to stem from an abstract kind of idealism coupled with a consciousness of what Wells called the race between education and catastrophe. This seems to have led to the great emphasis on mass media, which we note is given equivalent rank with education. It would be premature to judge at this stage where all this talk about mass media is going to lead; theorising about mass media is quite futile, and our judgment must wait until we see samples of its achievements in this sphere. If the mass-media approach is kept far away from the course of propaganda it could do a lot of good, but one gets a little uneasy when publicists back from *UNESCO* start talking about applying 'psychological warfare methods' to peace.

Dr. Huxley seems to have felt the need for a *UNESCO* philosophy, and he made, we think, a great mistake in trying to sell the conference his 'scientific humanism'. The simple fact is that almost any philosophy adopted at this premature stage could lead *UNESCO* on to very marshy ground. Dr. Huxley has no need to be disconsolate about the rejection of his creed for *UNESCO*. The International Labour Organisation, for example, has done very well without any elaborate philosophy, being content with the straightforward aim of securing and maintaining fair and human conditions of labour for workers in all countries. *UNESCO* may set its sights much higher, but its immediate objectives are practical ones like those of *ILO*, from whose record a great deal can be learnt. The staff of *UNESCO* will have to get down to thinking of its problems in terms of the individual human beings who will benefit from the organised attack upon world illiteracy and cultural starvation.

We are reminded of the French farmer who had been an important member of the French Resistance Movement and had paid the price for opposing the Nazis, with the killing of his family and the destruction of his home. After listening to a long explanation of the mechanics of the United Nations Organisation he said, "Well, its no use. I can plough my fields and take up a gun when freedom is threatened, but this thing is just too complicated for me."

The *UNESCO* stamp.

This anecdote has relevance to nearly all the principal organs of *UNO* and the specialised agencies like *UNESCO*. One can guess what impression the accounts of *UNESCO*'s conference made upon our farmer friend. If *UNESCO* has not yet gained public attention it is because little or nothing has been done to explain to the public what it is trying to do. Much of the talk in Paris meant nothing to a great majority of the people in the world. Yet the basic concepts of *UNESCO* are not hard to grasp. The farmer, peasant, or roadsweeper will make great sacrifices to ensure that their children get the opportunity their talents entitle them to; they realise that education is the key and parents everywhere set out to secure the best possible education for their youngsters. The concept of ensuring that no human talent shall be allowed to go to waste also motivates the community in planning equal educational opportunities for all and this concept can be carried to the international level. It lies at the basis of *UNESCO* which aims among other things to do for the world at large what individual parents aim at for their children.

Education is concerned, though not exclusively, with the acquisition of knowledge. It is concerned not only with basic knowledge that has been accumulated over the past centuries but also the new knowledge which was added to the common store only a year, a month or a week ago. To secure the application of that knowledge requires organisation far beyond provision of schools, teachers and books. In science, for example, facts are collected so rapidly that access to all the knowledge on a particular aspect of a particular problem is as difficult as finding a needle in a haystack unless one has the proper libraries, indexes and abstracting services. A great deal of the apparent elaborateness of *UNESCO*'s schemes arises from the need to keep facts where they can be found and used. It should be possible to explain these things simply, bringing to the explanation the vividness of a writer like J. B. Priestley. The success of *UNESCO* rests ultimately on the support it gets from the public all over the world. At the moment it is fair to say of *UNESCO* that "there can surely never have been so large a project launched with so little preparation of public opinion". Certainly *UNESCO* needs to give a little immediate attention to its public relations, which are no doubt brand-new and shining but which still won't work until the rust-proofing grease is taken off. In the initial stages of *UNESCO*'s existence we can understand that its public relations officers could not be allowed to say much lest delicate negotiations should be upset, but there is no need for them to be muzzled any longer.

Pressure of Light

That light exerts pressure is a fact of which non-scientists in general are quite unconscious. This is not surprising; for the intensities of radiation which we encounter in ordinary life this pressure is far too minute to be detectable. We should find it bizarre if by shining a light on a man we could knock him down, but nevertheless a minute force is involved, of the order of about 4·5 grams for a surface of a thousand square metres.

An intensity of radiation big enough to be felt would be so great that it would burn up every combustible object. We should, in fact, kill our man long before we had reached a sufficient intensity of radiation to knock him down with the beam of light.

However, small though the pressure of light is, it has a very great importance for the development of theoretical physics, and, especially in the application of physics to the study of the stars, the pressure of radiation associated with the very intense emission which occurs in stars is so great that it plays a most important part in the economy of stellar structure.

When we look upon light and other electromagnetic radiation as waves it is perhaps a little difficult to see how they can exert a pressure. However, modern physics has shown that waves and particles alike have a dual nature, and that we can, with equal validity, describe electromagnetic radiation in terms of showers of little packets of energy called photons. Where the photons are most numerous there the waves of the corresponding wave-picture are most intense: where the photons occur sparsely, there the radiation is feeble, and the waves very weak.

If for the moment we think of the photons as solid particles like bullets, it is easy to see how, when a stream of bullets is fired into a block of wood, the block of wood will be kicked backwards, that is, the stream of bullets can be regarded as exerting a pressure on the block. If the block were elastic and the bullets bounced off from the fixed block with speeds of return as great as their speed of impact, then it is possible to show that twice as much force will be required to hold the block in place as in the former case when the bullet stuck in the block.

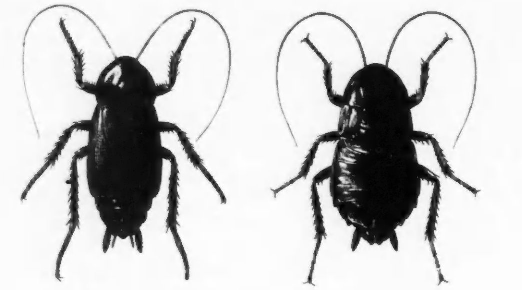
In the same way, a black surface which absorbs light will experience a certain pressure when light falls on it: if the same surface is silvered so as to reflect the incident light, the pressure will be doubled. Photons are not bullets, but, as far as the important property of carrying momentum along with them is concerned, their behaviour is sufficiently similar to that of bullets to make perfectly valid the comparison which we have just drawn between a beam of light and a stream of bullets.

The first experimental attempts to measure the pressure of radiation were made at the beginning of the present century by Peter Lebedev, a Russian physicist. A few years previously he had been compelled to invoke like pressure from the sun in order to explain the behaviour of the tails of comets. Comets are small solid masses moving round the sun in very elongated orbits. When they approach the sun, for reasons not yet fully understood, gas is evolved from the solid material, and streams out to form a long luminous tail, the feature of a comet which strikes the observer most forcibly. The comet's tail does not trail behind it, but points always away from the sun, and Lebedev advanced the view (still believed to be correct) that the pressure of radiation from the sun played an important part in causing these gas atoms always to move away from the sun.

The difficulties of measuring the pressure of radiation arise, not only because of the smallness of the quantity to be measured, but because it is also almost inextricably mixed with another phenomenon which has nothing to do with the pressure of radiation. A familiar sight in the windows of opticians' shops is a small glass bulb containing what looks like a little windmill with blackened vanes. This is a Crookes radiometer: when light falls on the instrument the vanes start to rotate, which looks, at first, as if the rotation were caused by the pressure of light. This is not the case. The bulb is exhausted as completely as possible, but there will remain, inevitably, a few molecules of residual air. The vanes of the little 'windmill' are blackened on one side only. These blackened faces absorb the sunlight and become hot: when an air molecule hits the hot surface it picks up energy from it, and moves off with enhanced speed. In giving this extra kick to the molecule, the vane is urged round in the opposite direction and the windmill is set into motion. The effect will not take place if the bulb is not evacuated, since, in this case, the molecule which has just collected extra energy loses it in collision with its companions before it reaches the wall of the container. In this case all the gas in the container gradually heats up. On the other hand if there is so little gas left that a molecule reaches the wall before striking another molecule, then the energy taken in by the vanes is dissipated to the walls, and the only molecules with more energy than they ought to have are the ones which have just kicked the vane and are on their way to hit the walls of the bulb.

Although this effect has nothing to do with the pressure of radiation, and is in fact the result of the unfortunate truth that it is impossible to evacuate a container completely, it is clear that it is an effect which is very difficult to eliminate. One obvious way to measure the pressure of radiation would be to let the radiation fall on one of a balanced pair of little 'paddles' hung on a fibre and to see how far round the paddle would be turned from its normal position against the twist of the fibre. The presence of air in the container would be a disadvantage, since if air were present and became heated, it might flow about inside the container and turn the paddle by blowing on it, again an effect which has nothing to do with light pressure. On the other hand, if the best possible efforts at removing the air always leave a little behind, the effect which is to be measured will be masked by the occurrence of the effect on which the Crookes radiometer depends.

Lebedev used a paddle system of the kind just described in a container in which a very high vacuum had been produced, and he arranged matters so that he could distinguish the radiation pressure effect from the effects due to the residual gas in the container. To him belongs the credit of the first experimental demonstration of radiation pressure, but his results were mainly of qualitative rather than quantitative importance. One important quantitative result did, however, emerge from his work. As we saw, a perfect reflector should show twice the effect of a perfect absorber, and in fact Lebedev found for a surface coated with platinum black (an almost perfect



The Common Cockroach (*Blatta orientalis*) × 1¼. Male, left; female, right.

absorber) a value of 1·1 times the effect expected for a perfect absorber, while for an aluminium surface—a good reflector, for which the expected effect was 1·8 times that of a perfect absorber—he found a value of 1·9. This represented an important confirmation of the theoretical expectations, as also did his results showing that the effect depended only on the intensity of the radiation and not on its colour.

Lebedev is also distinguished for his researches on electromagnetic waves, and to him we owe the discovery of electromagnetic waves with a wavelength of a few millimetres, rather shorter than the shortest which have been described as employed in radar devices during the war.

Lebedev incurred the displeasure of the Tsarist government, and, together with other university teachers, left Moscow in 1911. He worked for a time under difficult conditions at the Shaniavsky People's University, but his health was undermined and he died in 1912. Today the Institute of Physics of the Soviet Academy of Sciences is named after him, a measure of his greatness.

His work, published in 1901 was paralleled by that of two American scientists, Nichols and Hull, who worked at Dartmouth College, New Hampshire. They succeeded in balancing out most of the 'radiometer' effect and they made very accurate quantitative measurements, which demonstrated conclusively not only that the effect existed but that its numerical value had been accurately predicted by theory. In addition, they proved that the amount of the effect was constant and independent of the colour of radiation used.

Today, with all the publicity that has been given to the atomic bomb, it has become well known that matter and energy are interchangeable. We all know that when matter is annihilated energy appears, and the converse of this is that energy moving through space as electromagnetic waves must be associated with the transport of momentum, just as a moving material particle is. These ideas are of fairly long standing, but have only been forced on a more general public notice recently. In one second light travels 300,000 kilometres (186,000 miles) so that in a beam of light falling on a square centimetre all the mass associated with the light energy in a column 300,000 kilometres long and a square centimetre in cross section impinges on the surface under discussion in one second. This 'mass' is moving with the speed of light, and it is the arrest of this mass when the light is absorbed, or the push on a mirror when it is sent back in the direction from which it came, which is responsible for the pressure of light. It is an excellent example of the many approaches to almost any physical problem, and in particular of the two alternative ways which exist of describing any problem concerned with atomic particles, that all these ways of calculating the light pressure give the same answer. In particular it will be noted that the answer does not depend on the kind of radiation considered, i.e. its wavelength, but only on the total energy in the beam, in exactly the way that the pioneer experiments of Lebedev, Nichols and Hull demonstrated.

Doomed Fellow Traveller

NEARLY three-quarters of a million species of insects have been named and several thousand species are added to the list each year. Only a small fraction of them are pests, yet the damage they do to man's crops and stores and, indirectly, to his health, is an ever-present lesson in humility which is as obvious to the Maupassants and Czapeks as it is to the Darwins and the Fabres. Today we possess weapons which bring into prospect the possibility that another war would prove tantamount to a renunciation by man of his position of dominance among the animals. At the same time it is true to say that man does not yet possess the means of exterminating all the injurious insects which directly threaten his interests. This paradox is by no means so suprising if one compares the energy which is spent on the perfecting of weapons of war with that devoted to the improvement of insect-disinfestation techniques; the latter has never received the concentrated attention which chemical warfare has received, and little of the knowledge gained by chemical warfare services has ever been applied to disinfestation problems.

The insects as a group are recognised as the closest challengers to man's dominant position. The locust is still undefeated and continues to collect its tithes; so too the aphids which so nonchalantly spread virus diseases among our crops, while the malaria-carrying mosquito is far from beaten. And these are all insects whose depredations have been obvious for many years. The new insecticides such as DDT and Gammexane promise to alter the balance of the conflict between man and the insects. But the insecticides, old and new together, have not altered the balance decisively so far, even though the counter-attack of which the insects would seem to be capable (because of their adaptability which derives from extreme variability) has not had time to develop.

We are, however, within sight of controlling one group of insects, the group which is made up of man's fellow travellers—the bed bug, the louse and the cockroach, for example—which are external parasites or which share his dwelling. They have accompanied man on his travels, extending their distribution as man has extended his by missions of exploration, military expeditions and the development of trade routes. It seems poetic justice that the first insects which man is able to control should be the ones for whose spreading he was responsible.

The cockroach, a pest to which man has so long been the unwilling host, is the subject of a new pamphlet issued by the Natural History Museum (*The Cockroach*, by Frederick Laing, British Museum (Natural History) Economic Series No. 12, 6*d*.).

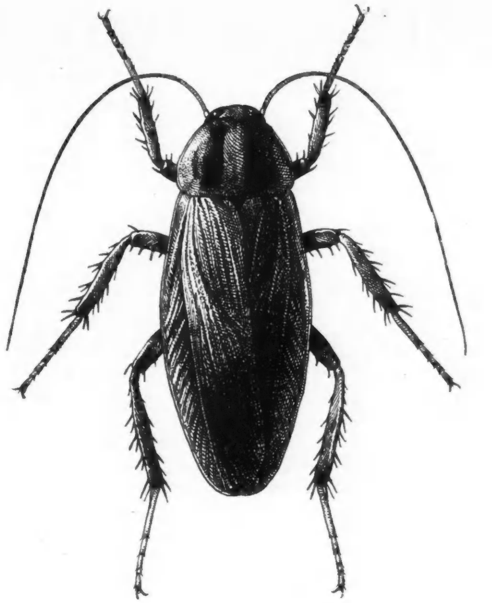
Means of eliminating the cockroach at least from a country like Britain are available, to judge from the section of the pamphlet dealing with methods of controlling the pest. A mixture of sodium fluoride and pyrethrum powder is lethal, killing the cockroaches that come in contact with it in about a day. (A commonly used mixture of borax and pyrethrum is less rapid in its effect, as are powdered derris and sodium fluosilicate.) DDT, Gammexane and Lethane look promising, but more trials will need to be made before they can be fully recommended. None of these methods kills the eggs (which are well protected in purse-like capsules) and repeated dusting or spraying with insecticide is necessary in order to destroy the young cockroaches which emerge from the egg cases. Trapping is quite simple (the grease bands used for fruit-trees are an effective form of trap), but it always leaves a breeding reserve so that it can never be more than a palliative. Fumigation with sulphur dioxide or prussic acid gas is suitable for clearing buildings and ships' holds, but is scarcely safe for amateurs to use. Aerosol bombs that produce an atomised spray of pyrethrin insecticides are likely to replace orthodox fumigation for dwelling-houses, restaurants and the like.

Supposing, however, an all-out drive against the cockroach was made in Britain: it would be no good eliminating it from buildings if no attention were given to the insect's lines of communication. The biological vacuum created by thorough disinfestation would soon get filled by cockroaches imported to this country among the cargo carried by merchant ships, which would have to be regularly fumigated if the insects were not to become re-established in dock areas from which they could again spread all over the country.

The way trade was responsible for the spreading of the cockroach is interesting. A good many years ago Miall and Denny in their monograph entitled *The Cockroach* said the cockroach was a native of tropical Asia and made its old way by the old trade routes to the Mediterranean countries. They were correct about the way it spread, but incorrect over its centre of origin.

In Britain there are two kinds of cockroach commonly found in houses. These are the Common or Oriental Cockroach (*Blatta orientalis*) and the German Cockroach (*Blattella germanica*). The Common Cockroach is about twice as big as the latter, and is dark brown in colour whereas the German Cockroach is dark yellow or light brown. The Common Cockroach used to be our dominant species, but is now outnumbered by the German which breeds more rapidly, and climbs with greater agility; the lay-out of modern buildings introduces a criterion of 'natural' selection which favours the better climber. Two other species, slightly less domesticated in that they are found in warehouses and hothouses rather than dwelling-houses, occur in Britain; these are the American Cockroach (*Periplaneta americana*), which is usually provided in zoology courses for dissection because of its large size, and the Australian Cockroach (*Periplaneta australasiae*).

While the names reflect the fact that none of these species is native to Britain, they are misleading in that they do not indicate the true country of origin. The confusion that has existed on this point has been made worse since most countries have been eager to export the honour of providing an insect of such ill repute with its original



The German Cockroach (*Blattella germanica*) × 5.

home. Indeed the cockroach used to provide the Germans and the Russians with a method of insulting each other without recourse to diplomatic notes; the Germans used to say that *Blattella germanica* came from Russia and should properly be called the 'Russian Cockroach', and the Russians returned the insult by nicknaming the insect the 'Prussian Cockroach'. The British, less sensitive in matters of national pride, were content to coin the common name 'Blackbeetle' (it is neither black nor a beetle!), with the more vivid and accurate terms 'Steam Bugs' and 'Shiners' as alternatives; our entomologists unfortunately perpetuated the geographical confusion prevailing elsewhere by simply translating the Latin names into English.

The Common Cockroach and the German Cockroach both hail from Africa. Neither species are found living in that continent "except as unwelcome guests in human habitations", to quote an American authority, James A. G. Rehn, who thinks, however, that free-living specimens of both species will eventually be found there. The evidence for the African origin of both species rests upon the factor that the 'centre of diversity' (to used Vavilov's term) lies in Africa; that is, there are in Africa many species of wild cockroach closely related to the Common Cockroach and its nearest wild relatives are undoubtedly in Africa. The same is true for the German Cockroach. From North Africa the two species were carried in Greek or Phoenician ships to Byzantium, Asia Minor and the Black Sea ports. As new trade routes were opened the two cockroaches spread over the rest of the world.

The Common cockroach is found living apart from man in the Crimea. This fact gave rise to the idea that the Crimea was the insect's centre of origin. This view was exploded when no related wild species were found in

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Artificial Fertilisers in Fish Farming

DAVID T. GAULD, B.Sc., Ph.D.

DURING the last half-century the fishing grounds of north-west Europe have been seriously depleted, the increase of fish stocks being insufficient to replace the crop removed by fishing operations. A recent international fisheries conference held in London voiced the general opinion that sea fisheries have reached, if not passed, the limits of profitable yield and that the technical efficiency of modern fishing boats and gear must be counterbalanced by measures of regulation and restriction if over-fishing is to be stopped. Such restrictive measures, if they can be enforced in practice, would only stabilise the yield; they could do nothing to increase the crop and so to give the industry a new chance of prospering.

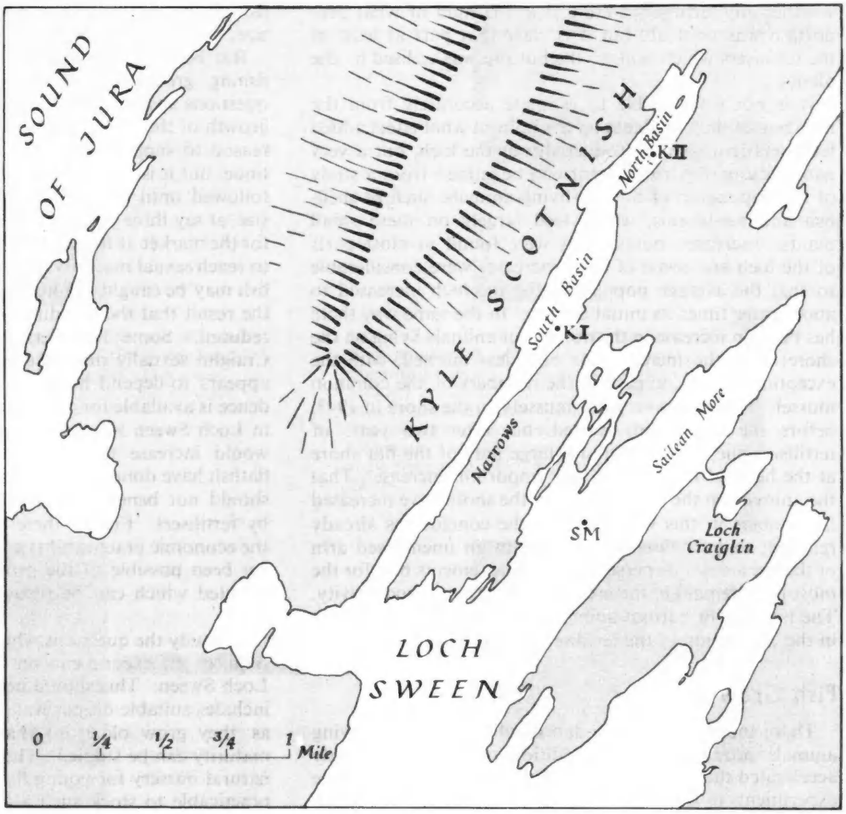
Why are fish stocks so limited? Apart from herring, most of the fish brought to the markets in north-west Europe live on or near the bottom in fairly shallow waters, where their most important foods are shellfish (e.g. cockles), and marine worms such as the angler's lug-worm. These in turn feed partly on smaller animals, some of which live on the bottom and others in the water above, and partly on microscopic plants which live either suspended in the water or lying on the surface of the mud. (The organisms which live freely in the water are called *Plankton*.) The microscopic plants are very simple in structure and of limited size, being one-hundredth of an inch or less in length. When they have reached their full size they divide into two more or less identical halves, which start growing again until their turn comes to divide. Because they are so small and because they may divide in this way as often as three times a day under favourable conditions, it is convenient to express the rate of growth of these minute plants in terms of increase in numbers rather than increase in size. The plants which form the ultimate organic source of the fishes' food depend for their growth upon the presence in the water of certain elements, in particular nitrogen, phosphorus and potassium, in the form of soluble salts such as nitrates and phosphates. The nitrates and phosphates are not particularly abundant in the sea and their scarcity is known to limit the amount of plant growth. This in turn limits the animal population. Thus the size of the fish population is governed by the amount of nitrates and phosphates in the waters of the fishing grounds.

On land, farmers have been able greatly to increase their crops by the addition of mineral salts which have been found lacking in the soil. Could not something similar be done in the sea? Would it not be possible to distribute nitrates and phosphates, which are commonly used as agricultural fertilisers, in suitable areas of the sea and so to increase the crop of fish?

Preliminary investigations into the possibility of using artificial fertilisers in the sea were started in Loch Sween, Argyll, and the first experiments were described in DISCOVERY in November 1944. In these experiments artificial fertilisers were distributed over a small arm of Loch Sween called Loch Craiglin, which was separated from the main loch by a dam, and the effects of adding fertilisers were followed up. The minute planktonic plants increased rapidly after the distribution of fertilisers and provided rich feeding for the bottom-living animals which, in turn, increased in number. These form the food of flatfish which, in consequence grew very much faster in Loch Craiglin than in unfertilised areas, reaching a length of ten inches in two years instead of in four to six years. One unexpected result of these preliminary investigations was that all the fertilisers were used by up the planktonic plants within a few days of distribution. This rapid utilisation of nitrates and phosphates suggested that fertiliser distributed in an unenclosed area might become at least partially fixed in bottom-living animals or fish before it could be dispersed by tidal movements. This speculation raised the question of the rate at which fertilisers would be dispersed by tidal movements. Nothing was known about such dispersion of a dissolved substance in the sea but there were two or three pointers which all suggested the same answer. In the first place, experience in laboratory and factory shows that violent mechanical agitation is required to effect the rapid mixture of liquids whose densities differ only slightly. Secondly, different masses of water in the sea can readily be distinguished one from another: for example the water of the Gulf Stream maintains its identity right across the North Atlantic due to small differences in density. Such density differences produce a distinct layering of the water in summer, which persists until the violent storms of autumn and the cooling of the surface water bring about a mingling of the layers. All these facts suggest the possibility that the boundaries between adjacent water masses of different densities might be sufficient to delay the dispersion of fertilisers added to the waters of a partly enclosed area of the sea long enough for them to be 'fixed' by bottom-living organisms. To test this hypothesis a further experiment was started in Kyle Scotnish.

The Kyle Scotnish Experiment

Kyle Scotnish is an arm of Loch Sween, roughly $2\frac{1}{4}$ miles long, and covering an area of 160 acres; it is connected to the main body of Loch Sween by a long, narrow portion which is at one point only 100 yards across. No dam was constructed here, as the primary object of the experiment was to see what happened to fertilisers when applied to an unenclosed arm of the sea. Above the narrow entrance the loch widens out into the first of its two basins, South Basin, most of which has a depth of 25–35 ft. The upper part, North Basin, is shallower, with a depth of less than 25 ft. at its deepest part. Fertilisers were added at monthly intervals and on each occasion 38 cwt. of sodium nitrate (or 30 cwt. of ammonium sulphate) and 12 cwt. of superphosphate were distributed; that is, roughly $2\frac{1}{4}$ cwt. of ammonium sulphate and 100 lb. of superphosphate per acre per annum, quantities rather smaller than those used by the farmer on his fields. To make this distribution as even as possible, a mixture of the two fertilisers was loaded into a large box on the stern of a motor boat and



shovelled out into the wash of the propeller, where it was thoroughly stirred into the water. Part of the fertilisers dissolved immediately and was utilised in the upper layer of the water; the remainder sank to the bottom.

On several occasions the fertilisers were distributed in the North Basin of Kyle Scotnish and their dispersal down the loch by tidal movements followed during the subsequent days. They were gradually dispersed over the whole of Kyle Scotnish in the course of one to four days, and in about a week the bulk of the dissolved fertilisers was used up. On some occasions it was possible to show that the enriched waters of the loch extended farther down the narrows at low tide and that, at the following high tide, these waters had moved back into the loch—a clear demonstration that the two bodies of water are distinct. On the whole it may safely be said that, under normal weather conditions, the loss of dissolved fertilisers due to tidal movements was not serious.

During spring and autumn the plants of the plankton responded to the addition of fertilisers as they had done in Loch Craiglin, multiplying five or six times in less than a week and then gradually declining in numbers. But in the summer months the response was much reduced because the planktonic animals were grazing heavily on the plants and consuming them as fast as they were produced. It was shown in Loch Craiglin that the added fertilisers were very quickly converted into plant tissues: the second step—the conversion of the plants to animal tissue—seemed to be almost as rapid, at least in summer. The planktonic animals multiplied and from June to September reached a population density three times greater than in Sailean More, the adjoining part of the open loch. This confirmed the beneficial effect of the added fertilisers, and the dense population of planktonic animals also showed clearly that these two water masses were separate and distinct—otherwise these minute animals could not have accumulated in the fertilised area, but would have been dispersed over the open loch.

Thus here are two lines of evidence pointing to one of the general conclusions of the experiment: the dissolved fertilisers were followed as they were gradually carried down the loch and it was shown that the loss due to tidal movements was not serious; secondly, it was shown that a plankton population several times richer than in the parallel arm of the loch could be maintained by the addition of fertilisers. It seems, therefore, that the water masses are sufficiently stable to make it possible to enrich unenclosed areas by the use of fertilisers.

The Bottom Community

As was said before, part of the fertilisers distributed falls to the bottom. What happens to these fertilisers? There is evidence that a part is brought up in solution to the upper layers, presumably by the action of tidal water movements. Are they also used by plants living on the bottom? Is there a loss by the chemical combination or absorption to the mud?

The important plants of the sea bottom are, like those of the plankton, microscopic in size. (The familiar seaweeds of the shore extend to depths of only 20–25 ft. and are of very slight importance in the economy of the sea.) Although much less is known about those bottom-living microscopic plants than is known about plankton, it is probable that they form a considerable part of the food of most sea worms and shellfish which live on the bottom, and so are ultimately of great importance to fish. In Kyle Scotnish addition of fertilisers caused these small

plants to multiply considerably. It is not yet known whether any fertilisers were lost in the mud or what proportion was used up, but it is clear that part at least of the fertilisers which sank to the bottom was utilised by the plants.

It is not yet possible to estimate accurately from the numbers of minute plants on the bottom what effect added fertilisers had on the productivity of the loch, but a very good idea of this enrichment can be gained from a study of the population of bottom-living animals, such as shellfish and sea-worms, which feed largely on these small plants. Increased populations were found in most parts of the loch and some of these increases were considerable so that the average population for the loch increased to about three times its initial density. In the same way there has been an increase in the number of animals living on the shore; here the increase has been less marked, with the exception of an increase in the numbers of the common mussel. There were very few mussels on the shore in 1943, before the experiment started, but after two years of fertilising they have covered a large part of the flat shore at the head of the loch—a very important increase. That the animals on the bottom and on the shore have increased in numbers in this way confirms the conclusions already reached, that fertilisers distributed in an unenclosed arm of the sea are not dispersed by tidal movements but, for the most part, remain in the area and increase its productivity. The increase in bottom animals represents a further stage in the conversion of the fertilisers into food for the fish.

Fish Growth

That the greater abundance of the bottom-living animals produced by the addition of fertilisers greatly accelerated the growth of the fish was demonstrated by the experiments in Loch Craiglin. Figures from Kyle Scotnish amply confirmed this conclusion. Here the rather sparse natural population, of which the most important species was the flounder, was supplemented each spring by the introduction of newly hatched plaice fry. In the autumn these young plaice had reached a mean length of $5\frac{1}{4}$ in. and put on weight approximately five times as fast as plaice normally do in the first six months. Plaice 18 months old caught at the same time had an average length of 8 in. and weighed nearly a quarter of a pound. Because plaice move into deeper water as they grow older it has not been possible to follow the growth of the plaice further in Kyle Scotnish. Had they stayed in the fertilised area, plaice would probably have reached the minimum marketable size of 10 in. in two years whereas on normal fishing grounds they take at least three years to reach that size.

But before these results can be applied to commercial fishing grounds some problems must be solved and questions answered. It has not been possible to follow the growth of the plaice for more than 18 months: there is no reason to suppose that the rapid growth would not continue, but it is at least desirable that the growth should be followed until the fish have reached a good marketable size, at say three years old. Secondly, if fish are big enough for the market at three years but still take four or five years to reach sexual maturity there is a possibility that too many fish may be caught before they are able to reproduce with the result that the breeding stock might become seriously reduced. Some flounders have been caught in Loch Craiglin sexually mature at three years, so that maturity appears to depend more on size than on age but no evidence is available for plaice. It was not possible to find out in Loch Sween whether round fish like haddock and cod would increase their growth rate in the same way as flatfish have done, but there is no obvious reason why they should not benefit from the increased fertility produced by fertilisers. Finally there is the important question of the economic practicability of the scheme. No estimate has yet been possible of the proportion of the fertilisers distributed which can be recovered in increased catches of fish.

To study the questions which have been left unanswered requires an experiment on a larger scale than that in Loch Sween. This should be carried out in an area which includes suitable deeper water to which plaice could move as they grow older, so that their further growth and maturity can be studied. The area must be one which is a natural nursery for young flatfish because it would not be practicable to stock such a large area by introducing fry from a hatchery. Finally, the area must be a fishing ground of which statistics of past catches are available.

It is obvious, however, that the application of fertilisers to fishing grounds in the sea does not lend itself to development by commercial concerns. There is no ownership of the fishing grounds and any attempt to improve catches by distribution of fertilisers must be done on a national, and, at a later date, on an international basis. It falls therefore to the Government to ensure that the work begun at Loch Sween is continued in some suitable area and to find out, by a large-scale test of the effect of fertilisers on a fishing ground, whether the sea fisheries of the world have not reached the threshold of a new expansion.

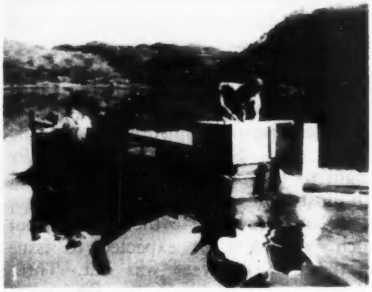
Fish Farming in Canada

In Canada artificial fertilisers are being tested as a means of improving the fertility of large lakes. Prof. B. W. Taylor of McGill University introduced the technique to Canada.

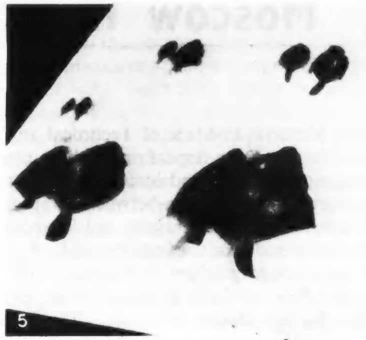
Controlled experiments were made in two lakes in the Laurentian Mountains near Montreal. To one of these lakes 20,000 speckled trout fry were added in June 1939. Four years later experimental fishing gave an average weight of three-quarters of a pound per fish. Then limestone and fertiliser containing nitrogen, phosphoric acid and potash were applied broadcast to the surface of the lake. Within a year the average weight of fish taken was one and a half pounds.

Interesting are the results from a Canadian trout hatchery. Small artificial ponds at the Gaspé Hatchery were treated with fertiliser at different rates per acre. A 10 p.p.m. (pounds per million pounds of water) treatment of a nitrogen, phosphoric acid and potash fertiliser gave a yield of 65 pounds of trout per acre. A 30 p.p.m. treatment gave 70 pounds per acre and a 50 p.p.m. treatment gave 121 pounds.

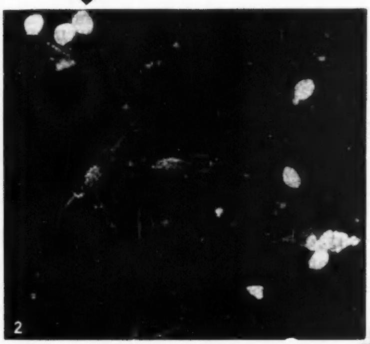
FROM FERTILISERS TO FISH



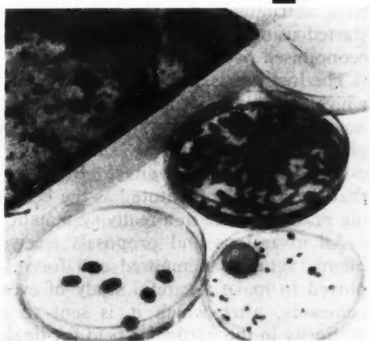
The fertilisers are shovelled out of the large box at the stern of the motor-boat and are spread by the wake. This photograph was taken during the Kyle Scotnish experiments.



Last link in the food chain is the fish. This photograph of the Loch Craiglin experiments shows the striking difference between fish from fertilised areas (bottom row) and unfertilised areas (top row). The two groups are respectively 12 and 18 months old. The two fish on the left show the size at which the experiment was begun.



First to benefit from the extra mineral salts are microscopic plants (phyto-plankton). This representative sample of phyto-plankton includes two large solitary diatoms, some smaller ones forming chains of cells, and a few oval, more densely coloured dinoflagellates.



The bottom-living animals benefit from the multiplication of planktonic organisms both animals and plants. A sample of these bottom forms has been sorted: the glass dish in the centre contains a large number of marine worms; that on the left bivalve shell-fish, and that on the right one cockle and several smaller shell-fish and crustaceans.

The multiplication of microscopic plants results in an increase in numbers of the animals which feed upon them; such as this small copepod, a typical planktonic animal.

ASPECTS OF INVENTION IN RUSSIA: I

Moscow Institute of Technical Information

M. MAKAROV

THE Moscow Institute of Technical and Economic Information is a huge depository of blue-prints and drawings, ranging from new industrial processes to minor technical gadgets. It acts as go-between in spreading information about the latest inventions and improvements among the factories and plants of the U.S.S.R.

In a country where technique is advancing so rapidly, and where so high a premium is set on inventiveness, this is a very necessary service. "Don't waste time duplicating inventions which others have already worked on—see us first," is one of the Institute's mottos.

The morning mail usually brings dozens of parcels, bearing the postmarks of almost all the Soviet Republics; for the Institute is in touch with thousands of enterprises and thousands of engineers. When, a few weeks ago, I saw the assistant director, Ivanov, he gave me several examples of the effectiveness of this service for distributing inventions. About three months ago, for instance, blue-prints of a new lathe fixture for grinding control gauges were distributed. And to date twenty-nine factories have started using it, with the result that in two months they economised over half a million roubles.

The Institute is, of course, not the only channel through which technical information is disseminated. All the Soviet ministries do work along this line among their own plants, while industrial enterprises themselves often exchange information direct. But experience has shown that the Moscow Institute has the best facilities for carrying on this service in a really systematic way.

All inventions and proposals received are very thoroughly vetted. A hundred and forty specialists are employed to make a careful study of every novel idea that comes in, after which it is sent to some outstanding authority in the particular field for final appraisal.

Whatever passes this rigorous test is then published in pamphlet form, in editions of several thousand copies, and mailed to the enterprises and institutions on the Institute's subscription list. Such pamphlets usually consist of about eight to ten printed pages of detailed descriptive text with illustrations.

During the first six months of 1946 the Institute put out over 1500 such pamphlets. It expected to issue as many more by the time the year was out. Three thousand worth-while inventions every year seems not bad going.

Of course, both the inventors and the enterprises from which the inventions originate are delighted to have their discoveries propagated in this way; and the faster it is done, and the more widely such material is distributed, the better they are pleased. There is no such thing in a socialist country as putting an invention on the shelf, or keeping it as a closely guarded 'trade secret' belonging to one single individual or firm.

There is a special patent office in the Soviet Union which grants and registers patents for all original inventions. The Institute also distributes descriptions and blue-prints of such patented inventions that have already been applied by some plant. The inventor's patent rights are, of course, insured.

The Institute's staff also keep in touch with technical progress abroad, and receive hundreds of foreign technical journals. The most interesting papers and articles in these are translated into Russian and mailed to subscribers. The Institute's library contains all technical books published in the U.S.S.R. and all foreign technical catalogues. It boasts a subject index of several million index cards. This enables references to source materials on any given technical problem to be easily obtained.

ASPECTS OF INVENTION IN RUSSIA: II

Incentives and the Soviet Inventor

FRANCIS HUGHES

To appreciate the relation of invention to incentive in the Soviet Union, it is essential to be convinced that the bases of factory management, technical development, initiative, luck and stupidity are no different in the Soviet Union from those existing under industrial conditions in the Western democracies. They are not political questions. The frustrated inventor, the frustrating bureaucrat and the friction which wastes both time and opportunity appear to be omnipresent under either system.

Examples are available in support of this conviction. In each monthly issue of the official Soviet invention journal there is a section devoted to correspondence with the editor. These letters are of two kinds: requests for information and complaints requiring advice. The editor, although so to speak a Government official, rarely hesitates to give a frank and, as far as lies within his power, an adequate answer. The following representative extracts have been taken from a survey covering 141 questions and answers published in the twelve issues of the journal for 1939.

The Chief Accountant of the Kalinin Engineering Works 100 miles NW. of Moscow writes to the editor of his suspicion that the ". . . workers in the technical department, especially the technological ones (i.e. development engineers); . . ." are deceiving him, claiming 50% of the awards scales appropriate to the devising of new techniques whereas all they had done was to apply known

techniques—for which no reward is admissible. Some of them go even further by 'suppressing' certain obvious details which need not necessarily appear on the production drawings; then they 'round up' these omitted details into a concrete suggestion for which they claim awards from the Inventions Fund. The editor in this instance is evasive—unlike his usual practice—and does not accept the insinuation of the chief accountant, merely stating that technologists are entitled to awards for work done in the ordinary course of their duties, but on a reduced scale, and that 'creativeness and orginality' must be the standards by which awards are scaled.

Extra Holidays

The question of extra holidays additional to awards is a constantly recurring one. Here are three illuminating examples. Question: "Can a chief engineer claim two weeks supplementary holiday for a technical improvement adopted by his plant?" Answer: "Yes, technical administrative workers can claim two weeks if the economy of the technical improvement is not less than 25,000 roubles." The answer goes on to say that for a chief engineer such additional leave must be approved by higher authority. Another chief engineer, Ziablikov, writing from Moscow, complains that he has been refused two weeks' additional leave even though one of his ideas was adopted and resulted in an economy of nearly 12,000 roubles. He admits that the idea was not original and that it was borrowed from published literature. The editor replies that borrowed suggestions qualify only if the economy is not less than 50,000 roubles. From Chapayevsk, a town approximately 300 miles north of Stalingrad, comes this question in the name of Citizen Bocharov—the word 'citizen' is invariably used where the writer has no title: "What is to be done when the author of a scheme showing effective savings of 1,000,000 roubles is naming several other persons as co-authors in order to get them an extra two weeks' holiday?" The editor explains that these holidays are granted to production workers for each 10,000 roubles of economy, and to executive workers—administrative, technical and scientific—for every 25,000 roubles of economy but only when the scheme submitted comes from a company of workers (a 'company' being one group in a 'shock brigade') registered with the local trade union. When a scheme is submitted by a group of workers they merely share the two weeks between them. This is not the only instance of an attempt by some bright fellow to help his colleagues obtain additional leave.

From Sverdlovsk in the Urals comes this question submitted by the Director Kiselev: "Can an Authorship Certificate be granted for an invention developed by a laboratory?" Answer: "Yes, either to the individual concerned, to a group of persons, or collectively in the name of the laboratory itself." A similar problem is presented by a woman member of a scientific research institute in Moscow. She complains that an Authorship Certificate for her invention is being denied on the grounds that it should be issued in the name of the institute where she works. The editor replies firmly that if she is the true and only inventor the Authorship Certificate must be issued to her, and that the name of the institute may be incorporated in the application if they have an interest.

There are many references in these correspondence columns to Invention Dispute Commissions, as in this question: "Is it right for the factory director or chief engineer to appoint the members of the Invention Dispute Commission?" It is not right. Such a Commission is only competent if selected as follows ". . . a representative from the regional or local soviet as chairman, one representative from the factory management and one representative from the Trade Union." In another case an inventor has been refused an award for a technical improvement adopted by a concern which is not his employer. The editor advises him to apply to the Invention Dispute Commission of the concern from which he is claiming the award and not to the Commission attached to his own concern.

The editor informs Citizen Gamchekelov of Batum that patent fees are paid by the licensee if that is a condition of their agreement; if not, they are paid by the patentee. In another answer on the same subject he adds: "In the case of the patent being cancelled because of non-payment of the fees in the prescribed time, the licensee can claim damages from the patentee." Elsewhere he advises a widow of Kuibishev that she can exchange her late husband's patents for Authorship Certificates as only three months have elapsed since they were granted and six months' grace is allowed. No registration fees are payable on Authorship Certificates since they belong to the State whilst patents continue to be private property and are therefore penalised.

Here finally is a question which is frequently asked in Western countries having a system of invention legislation different from that of the Soviet Union. It comes from Kharkov. "Is it right for an inventor to give a verbal account of the main essentials of his invention before making an application in order to excite interest in his invention, and will this account serve as a disability to the issue of an Authorship Certificate?" According to Soviet legislation, applications will be valid up to six months after verbal disclosure.

Things in Common

These examples have been presented to show how similar are the circumstances surrounding the Soviet and the Western inventor. There is nothing altruistic about the Soviet invention system and there is no deliberate appeal to national unselfishness in its procedure. Even on the lowest level of simple improvement or avoidance of waste, inventive genius is elusive, and its development is very much dependent upon the individual fulfilment of personality. Inventors cannot be commanded, even in the Soviet Union; they must be coaxed. Nor can the coaxing be selective: it must be indiscriminate since invention is spontaneous and there may be no continuity of subject between successive inventions by the same inventor. Probably for these and other reasons the Soviet legislators agreed to confer liberties or rights which correspond in many respects to Western standards. On the other hand it should be remembered that the prizes in the British, American and other Western invention systems are not based upon any natural theory of common justice or individual liberty despite the reference in the American Constitution to the contrary. Western legislation can be justified only by results, and there is little doubt the

ECONOMY (*total gross savings in one year*)	*AWARD*		
	Invention	*Improvement*	*Suggestions*
£10	£8	£6	£4
£30	£9	£7·5	£4
£300	£46	£37·2	£18·8
£3000	£280	£156	£79
£30,000	£1340	£690	£345
£360,000	£8000	£4000	£1000

principle of such legislation has been so justified, despite its monopoly features. The effectiveness of material monopoly (i.e. rights) and the fulfilment of individual personality seem to be intrinsically related. For the short period of fifteen years during which Soviet invention legislation has been operating, it is our problem to examine whether the results are proportionately equal to the results under Western systems, other things being equal. If they are not, then the fault lies in the Soviet system of incentives.

At the present time in the Soviet Union the encouragement of technical initiative, invention and research appears to be operating on three distinct levels—low, medium and high. In principle their invention legislation covers all three, but it is doubtful whether the high level is much affected by the laws in force. It may have been for this reason that special Stalin Prizes amounting to more than £500,000 a year were introduced. The expansion of the Academy of Sciences of the U.S.S.R. since 1917 provides a good example of the need to supply incentive on the high level. In 1725 there were 15 academicians, in 1925 there were 48 academicians and, in 1945, 142 academicians and 208 corresponding members. Of these, 109 academicians and 137 corresponding members (together with some four thousand senior and junior scientific workers) were serving in the various institutions of the Academy, which in 1945 comprised 53 scientific institutes, 16 laboratories, 35 research stations, 15 museums and 11 provincial sections, the whole organisation operating through 31 committees. The revolt of Kapitza against political direction and the absurdity of the new genetics developed by Lysenko may persuade the authorities that science and politics do not mix. All that politics can supply is indiscriminate incentive and ample facilities for individual fulfilment.

The medium level, which has hitherto proved a most beneficial accelerator of national wealth in the Western democracies, is badly documented and does not appear to be as yet a factor of national importance in Russia. It includes perhaps 100,000 individuals. At the same time it must be remembered that it is extremely difficult if not impossible to judge qualitatively output of invention at any precise moment in any one of the Western democracies; patent statistics are a quantitative index, and do not indicate quality of invention. The Soviet output of invention certificates for novelty and utility is approximately one-third of the number of patents taken out by British citizens and residents, and one-tenth of that for United States' citizens and residents, bearing in mind that Soviet examination standards appear to be somewhat stricter than either the British or the American. As in the Western democracies there are no figures for total awards or royalties paid in any one year, which would provide a qualitative comparison.

On the low level, the level of simple improvement and waste avoidance, there is evidence of very considerable activity in Russia, which corresponds with the rapid expansion during the recent war of industrial suggestion schemes in the United States, the United Kingdom and Germany. For instance in the Commissariat of Medium Machine-Building for the year 1940, 46,145 suggestions were accepted, of which 37,743 were actually exploited during that year. The Commissar—now Minister—Malyshev criticises his executives for holding up the remaining 18% of suggestions that were accepted. His report reads: "From the exploitation of inventions and technical improvements in these factories alone (he is referring to three large factories under his control) the State benefited last year to the extent of over 44 million roubles (£1,760,000)" in savings which included economies of "over 9000 tons of ferrous metals, nearly 1500 tons of non-ferrous metals and 2500 tons of fuel oil."

Award Scales

The table shows typical examples of Soviet awards taken from the three scales applying to inventions, technical improvements and simple suggestions.

When they were originally introduced by the Act of 1931 the minimum awards (£8, £6 and £4 respectively) and the maximum awards (£8000 and £4000—but not the £1000 maximum for simple suggestions) were set at half the figures now in force, which were introduced in 1942. No awards or royalty rates were set for Soviet patents since in principle this revenue is subject to free negotiation, as can be seen from three of the questions and answers given above.

The idea of basing awards on savings is not unreasonable. It is true that savings cannot always be estimated by strict accounting methods and must often be left to the discretion of management, but that condition is also true of a great part of normal business in the Western countries. The idea is not popular in connexion with Joint Production Suggestion Schemes in the United Kingdom, but during the war it was generally accepted in the United States. "With most suggestions it is always possible to calculate a definite saving, and where this is the case it is general practice to pay the person making the suggestion 10% of the gross savings brought about by the suggestion during the first full year of its operation. Some companies pay 10% of the net savings, deducting the cost of putting the suggestion in operation from the gross figure." This is from a statement issued by the American National Association of Suggestion Systems. For instance from March 1 1941, to July 1 1946, the Pullman Company of the U.S.A. accepted 25,654 suggestions and paid out £80,389 in awards, basing all these payments on total gross savings of £560,944. It is interesting to note that the usual minimum in the U.S.A. for a suggestion award is £1½; the maximum varies from £250 to no limit against £4 and £1000 in the U.S.S.R.

Of course such comparisons are dangerous. In theory the exceptionally low Soviet standard of living makes their award scale for suggestions even more attractive and since

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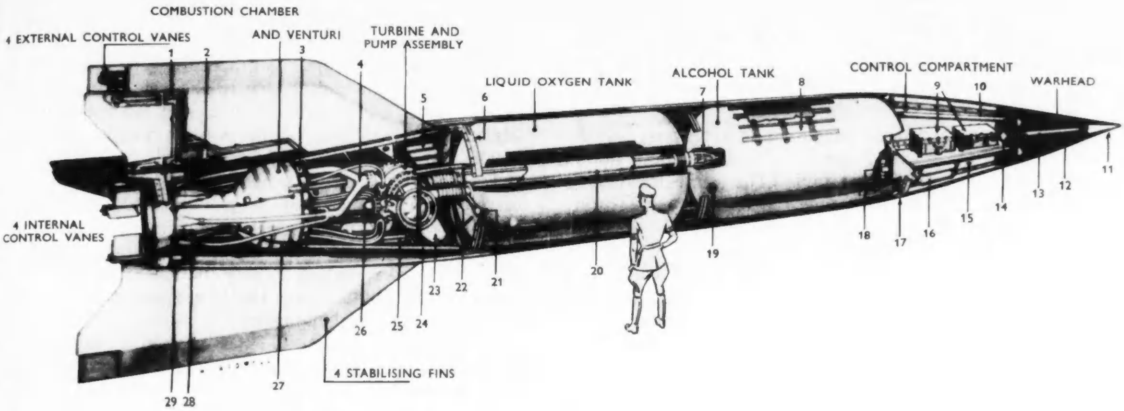


FIGURE 6.

[Cont. from p. 384 of last issue

Power Plants for High-Speed Flight

T. NONWEILER, B.Sc.

TURNING our attention from aircraft to the field of guided missiles, we are confronted with one of the most notorious uses to which the rocket has been applied. It is interesting to note that work on the A-series of rockets, of which the V2—or A4, as it was known to the Germans—was an example, was started in Germany as long ago as 1932. By 1938 only small progress had been made. Disregarding the moral issues involved in the use of this type of weapon, one cannot but wonder at the progress made by Gen. Domberger, Prof. von Braun and the scientists at Peenemunde in the next six years on such an immense technical project.

The V2 and its components are sketched in Fig. 6. The rocket unit, which developed a thrust of 55,000 lb. for over a minute, utilised liquid oxygen and 80% methyl alcohol as the two fuels. An auxiliary fuel pumping device was included, a small turbine being driven by the reaction of hydrogen peroxide with sodium permanganate, which produces steam at high pressure.

The general scheme of operation is very similar to that outlined for the Walter unit. The reaction temperature rise of the two main fuels is, however, about 3000° C. in this case, and special provision has to be made for the cooling of the combustion chamber and exhaust nozzle. To provide for this, the nozzle has a hollow lining within which some of the alcohol is circulated before being injected into the combustion chamber.

Problems of storage and evaporation make liquid oxygen difficult to handle. However, its performance is superior to hydrogen peroxide, the V2 unit with a combustion chamber pressure of 20 atmospheres giving a specific impulse of 208 secs. at sea-level increasing to over 240 secs. at high altitude. (This increase is due to the decreased atmospheric back pressure over the jet exit at high altitude.)

Two-thirds of the weight of the V2 on take-off was due to the fuel carried, and the maximum range of the missile ever recorded (on two occasions) was 225 miles. The large scatter in range observed during the London bombardment was mainly due to the fact that the manner in which the thrust deteriorated when the fuel had been cut off—after receipt of the appropriate signal from the auto-controls—could never be predicted. The error resulting from this cause was to some extent alleviated by the premature reduction of the thrust to 20,000 lb. a few seconds before the 'all-burnt' stage. Any variations in the rate of thrust-decay after 'all-burnt' would not then of course be so important. The ultimate answer would be a drawn-out and controlled reduction in thrust, but this is difficult to attain because of instability due to excessive reduction of fuel flow through the jet. Similar difficulties were encountered in the 'warming-up' stage at the beginning of the flight. The automatic flight-path controls could not be made to take over at the precise instant when the thrust became effective. Until these problems are successfully solved, this form of weapon can never achieve 'pin-point' accuracy.

A projectile of this type could serve scientific progress very profitably as a high-altitude meteorological instrument of observation. Recent press reports told of an American rocket-propelled missile which had made an ascent to an altitude of nearly 50 miles, and was to be used for this purpose; the Germans, too, had intended to use the V2 for meteorological experiments.* At present, very

* The Americans have recently been firing V2's controlled to nearly vertical trajectories. The culminating feat of their tests was the achievement of a maximum height of 104 miles on July 30th, 1946. (See Fig. 1 in first half of this article.)

Full details of the American meteorological projectile—the WAC CORPORAL—are contained in the September 1946 issue of the *Journal of the British Interplanetary Society*. The two fuels used for this rocket are nitric acid and aniline, fed by compressed air.

little is known about conditions in the upper atmosphere above about 35 kilometres—the limit of sounding balloon ascents; further information on conditions above this height would be of very great value to many branches of applied science.

The V2 is readily adaptable to this purpose by the removal of the warhead, which operation would not in itself make the projectile unstable. The warhead would be replaced by a box containing the necessary measuring equipment to record, for example, brightness of background, quantity of ozone, density (by means of a spectograph), temperature, Bourdon tube measurements of pressure, cosmic ray intensity, intensity of ionisation, and so on. The rocket is fired vertically and the trajectory followed by microphone (or radar). The point at which the velocity approaches zero could be established and a radio signal could effect the detachment of the recording box from the rocket. The former would then fall freely, a parachute arresting its motion in the lower atmosphere; readings are taken during the descent. Radar could be used to determine accurately the height of the box at any instant.

So that the parachute may open at high altitude it would be necessary to construct it of a number of gores built of two thicknesses of material, the space between being inflated with compressed air when the box is detached.

Two-Stage Rocket

Later projectiles planned in the A-series of rockets were designed to be long-range gliders, presumably for transatlantic use. A two-stage rocket system was to be used: the A4 missile was to have wings added, and a large 200-ton jettisonable boost rocket fitted to the base of the fuselage. The booster, or first-stage rocket, propels the missile to an altitude of 80,000 ft., at a speed of 3000 m.p.h. The booster is then jettisoned and the V2 carries on under its own power until a speed of over 6000 m.p.h. is attained. Being then in very rarified air the missile follows a parabolic trajectory until it returns to the region of denser air, when the aerodynamic controls can be used to pull it out into a glide. This occurs at a height of about 20 miles, the speed then being about 7000 m.p.h. With this large amount of kinetic energy to dissipate, a glide of some 2000 miles is not impossible (see Fig. 8).

This missile could travel between London and New York in less than an hour; however, it is unlikely that there would be many passengers eager for the trip. The accelerations during the initial powered climb and during the pull out are very large and sustained: sufficient to render a man completely powerless to move. (During the free trajectory the acceleration is practically zero.) Moreover, aerodynamic skin-heating due to the heat transfer from the boundary layer of the air in contact with the missile, would give rise to a maximum skin temperature of about 1000° C. at the beginning of the glide.

They also planned to provide a cockpit and an undercarriage and use the missile as a high-altitude supersonic bomber, the return to base being included in the glide. The wing-loading when all the fuel was used was small enough to make landing an easy matter. The height and speed of this bomber over the target would put normal interception out of the question.

There is no space here to enter into a full discussion of the multitude of guided missiles which the Germans were designing. Most of them employed fuel systems using nitric acid as an oxidising agent, the fuel being fed by compressed air or nitrogen, as the duration required was not long. The Germans believed that this form of anti-aircraft missile was a more economical proposition than ordinary A.A. fire: the largest of these guided missiles, 'Wasserfall', cost about £500, whereas the average cost of A.A. shells for every aircraft destroyed was some £20,000. The total weight of 'Wasserfall' is 3 tons, of which 200 lb. is warhead. The missile would be controllable from the ground up to a height of about 50,000 ft., and within a radius of 30 miles. If only one in forty of these missiles was to intercept its target the experiment would be no more costly than that due to the expenditure of anti-aircraft fire, and certainly the results would be more damaging.

The Athodyd

The athodyd, which may be better known to readers as the 'propulsive duct' or by the American term 'ramjet', has been mentioned as the other form of power plant suitable for high-speed flight. As yet it has had but little practical application, and experimentation is still in the early stages and the accompanying teething troubles are many. Consequently all that can be attempted here is a description of the factors involved in athodyd design, and a few suggestions as to its future use.

Essentially the athodyd consists of a hollow tube or duct of circular cross-section; Fig. 7 is a diagram of the athodyd in longitudinal section. Air is admitted at a velocity V_1 at the intake; in passing through the diverging portion or *diffuser* the air is retarded to a velocity V_2, and there is a corresponding rise in pressure. From the diffuser the air passes on into the combustion chamber into which fuel is injected and burnt. The density of the gas decreases as it is heated and its velocity increases to a value V_3. The gas then accelerates through the constricted outlet nozzle. The gaseous mass has increased in this process, and the velocity of the exit gases is greater than the velocity of the gas admitted to the duct so that a thrust results. The ratio between V_2 and V_3 the velocity of the duct

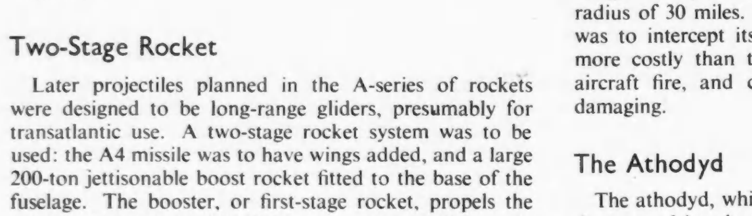


FIG. 7.—Diagram showing action of the athodyd.

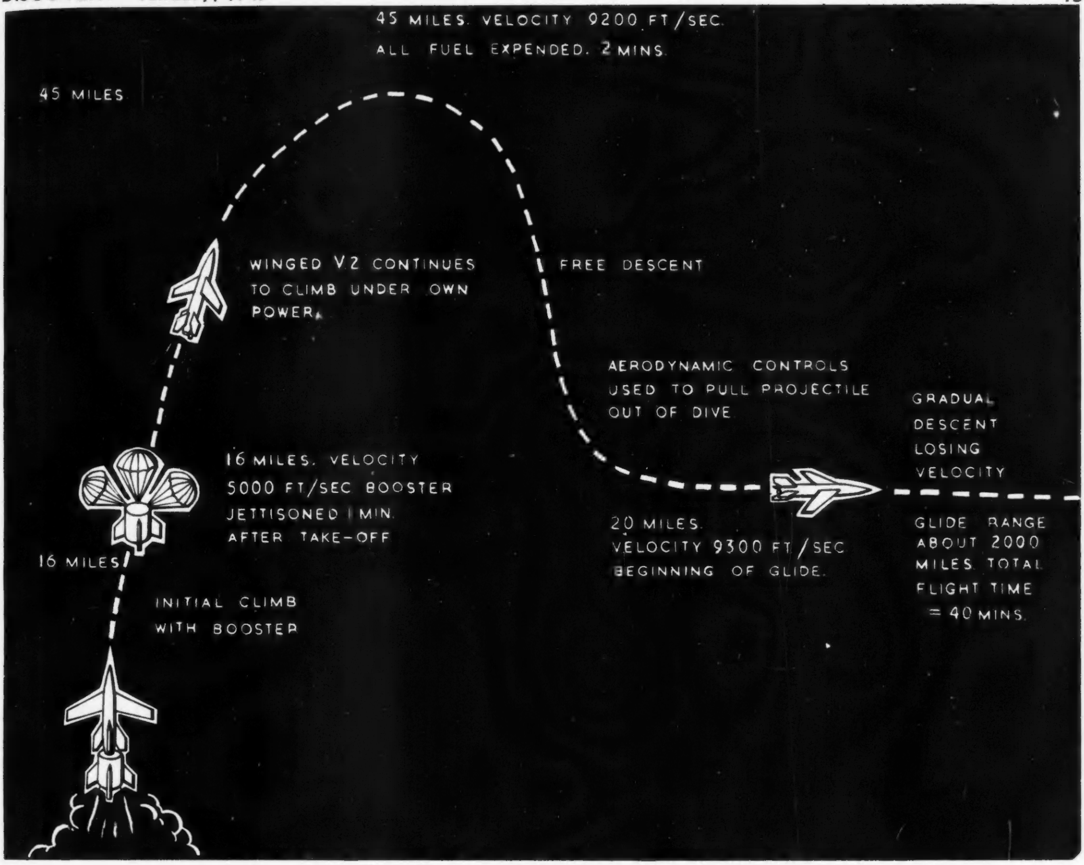


FIG. 8.—The initial path of the proposed German long-range rocket glider.

through the air, is dependent only on the shape of the diffuser; consequently the jet thrust depends chiefly on the dynamic head of air due to the forward motion of the duct. Thus the thrust of these units varies proportionately to the air density, and increases as the forward speed increases.*

The athodyd can be regarded as an extremely simplified form of the gas-turbine engine, but without any rotating parts. As readers may know, in the gas turbine there is a rotating 'fan' in the intake which compresses the gas before passing it into the combustion chamber. This compressor is driven by a turbine that is rotated by the hot gases exhausted from the combustion chamber before they finally emerge as the jet. The compressor and therefore the turbine become superfluous at high speeds, as the air may be sufficiently compressed simply by slowing it down. To illustrate this point, it may be stated that, by slowing down almost to rest air that enters the duct at 1500 m.p.h. and at ordinary sea-level pressures, the pressure of the air is increased four times; that is, to practically 60lb. per square inch.

Low-speed flight tests on the athodyd have been carried out by Sänger in Germany by mounting a duct on top of the fuselage of a Do 217 aircraft. He worked with ducts operating at high combustion-chamber temperatures and large diffuser compression-ratios. When the speed of the aircraft is increased, troubles may arise because of air flowing round the lip of the intake at speeds near that of sound. A sufficiently large compression ratio causes such a drop in the velocity of the air in front of the duct that these difficulties are avoided. Sänger obtained a thrust coefficient (see footnote on this page) of 0·4, implying a propulsive force of some 2500 lb. for a duct of $3\frac{1}{2}$ feet diameter at an air speed of 500 m.p.h. This is large in comparison with the usual thrust obtained from such units, and was only obtained at the expense of efficiency—the specific consumption being 12 lb. of fuel consumed an hour for every pound of thrust.

The fuel is injected through a circular grille of tubing containing numerous injection nozzles with tangential passages to provide swirl for mixing the fuel and air well together. Although the combustion temperature was high, the surface of the duct only reached 500-600° C., so that

* The thrust is given by the mass of gas flowing through the duct multiplied by its change in velocity through the duct, i.e.

thrust = air density $\times V_2 \times$ area of combustion chamber $\times (V_4 - V_0)$
= air density $\times V_0^2 \times$ area of combustion chamber $\times \frac{1}{2}C_T$

C_T is the *thrust coefficient;* a factor dependent on the shape of the diffuser, the temperature at which the fuel is burnt and the aircraft's forward velocity.

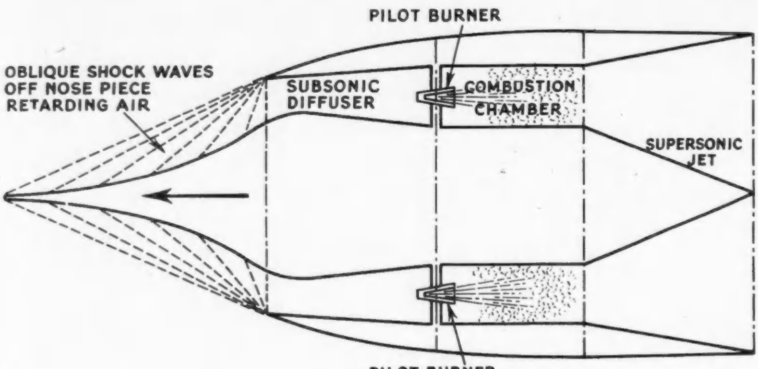


FIG. 9.—Diagram illustrating the Oswatitsch type of diffuser for use on athodyds travelling at high supersonic speeds.

there were no complications involved in keeping the engine cool. Operation at lower temperatures decreases the thrust, but increases the efficiency.

Walter's of Kiel, the rocket engineers, tested ducts operating at lower temperatures, and here the thrust coefficient was reduced to about 0·3, but the fuel consumption per hour was also reduced to 7 lb. per pound of thrust, which represents a large increase in efficiency. These ducts with less thrust and greater fuel economy are suitable for medium-range aircraft, whereas Sänger's work was intended to provide an alternative to the rocket for short-duration aircraft.

Much of the thrust obtained by these ducts was cancelled out by the drag caused by the cowling, superstructure and fuel injection system. To ensure complete mixture of fuel and air a very long duct was necessary, and overall lengths of more than five diameters were needed. This in itself involved large frictional losses. With this in mind a German worker, Pabst, set about the design of a duct with a short combustion chamber. This used a gaseous fuel, which was mixed turbulently with the airstream. Pabst evolved a burner which was conical in shape, the fuel being injected through a narrow annular slit near the base of the cone, the apex of which pointed downstream.

The short length of flame made possible a short combustion chamber, and the external drag was cut down to about half that of the conventional type of duct. The advantages of this system appeared in the improved thrust and efficiency—the thrust coefficient was about 0·4 and the specific consumption 4 lb. per hour per pound, using vaporised petrol, which represents an efficiency of 7%. In this engine the fuel is vaporised and superheated before being fed into the burners; this uses up about 2% of the total fuel consumed.

Tests were also made using gaseous hydrogen as a fuel and the specific consumption was further decreased to 1·5 lb. per hour per pound thrust. However, unless the hydrogen is stored in liquid form this type of fuel would appear to have no advantages over petrol despite its higher calorific value; for the large weight of the containers necessary to store the hydrogen would far outweigh any saving in fuel weight resulting from the reduced consumption.

Another German worker, Lippisch, designed a coal-burning athodyd for use in a trans-sonic aircraft.* The airframe used is itself of particular interest. The aircraft is of a 'flying wing' design, with the wing in the form of an equilateral triangle. In one particular model the pilot's cockpit was housed in the large vertical fin; an innovation of some interest.

The heating element of the duct he intended to use on this aircraft was to be composed of small coal pellets arranged to form a disc which was placed perpendicular to the airstream and was rotated to ensure uniform burning. The surface of the coal was to be ignited with an acetylene flame. An exit nozzle of rectangular cross-section was envisaged, with movable upper and lower surfaces to vary the exit area; such a nozzle is a useful innovation, as a fixed nozzle can only give optimum efficiency at one particular flight speed and one specific combustion-chamber temperature.

The types of athodyd so far described are applicable at speeds up to, say, about 1000 m.p.h. At higher speeds than this the losses due to the shock wave which forms in front of the diffuser assume serious proportions. A shock wave precedes all bodies travelling in air at supersonic velocities: it consists of a region in which variations of pressure and density are intense. The presence of a shock wave implies a loss in the dynamic head of air available for compression. The type of diffuser already mentioned gives rise to a perpendicular shock at or in front of the intake, and it is precisely this type of shock wave that results in large losses in compression at high supersonic speeds.

On the other hand, oblique shocks at high Mach numbers imply no greater losses than do perpendicular shocks at Mach numbers only a little greater than unity. If therefore the air could be retarded by a succession of oblique shocks before meeting the perpendicular shock as it entered the

* Aircraft designed to fly at speeds near or above that of sound.

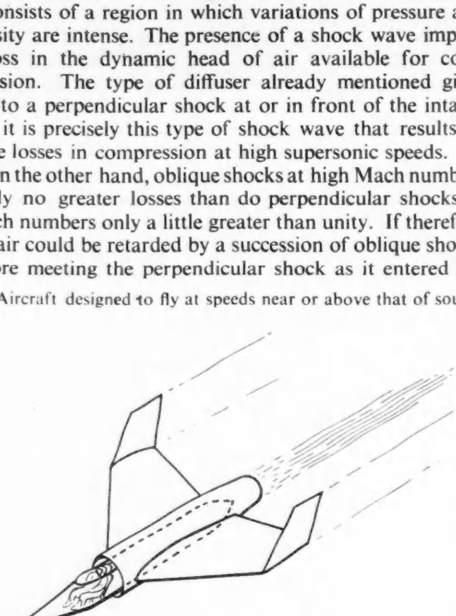


FIG. 10.—Sketch of a supersonic aircraft based on the Oswatitsch athodyd. The pilot would be accommodated in the projecting conical portion of the diffuser.

duct, the losses would be less than if the retardation were brought about by a single, large, perpendicular shock. With this in mind, a German scientist, Oswatitsch, set out to develop a diffuser which brought about retardation in this way. The method used is shown in Fig. 9. At a Mach Number of 3 the efficiency is greatly increased and may be as large as 40-50%, working at combustion temperatures of about 1700° C.

The drag of such a unit would of course be high, but Oswatitsch was chiefly concerned with the design of a remotely controlled missile, in which he intended to make the internal shell and nose cone fulfil the functions of a fuselage, to store fuel, instruments and warhead. Suitable heat insulation would of course be necessary. Owing to the low fuel consumption a range of some thousand miles could be achieved in level flight at speeds between 1500 and 2000 m.p.h. if this missile was fitted with wings and boosted to an altitude of about 80,000 ft., like the long-range two-stage rocket already mentioned. From many viewpoints this system would appear to have obvious advantages over its rocket counterpart which requires so much larger velocities to achieve the same range.

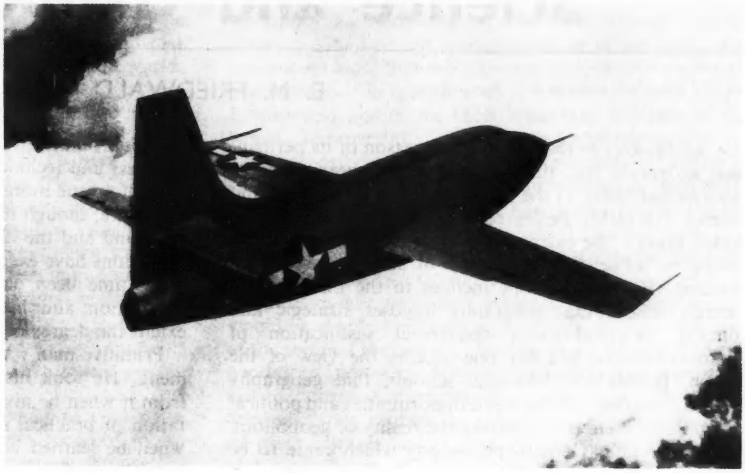


FIG. 11.—The American Bell *XS*-1, which may be the first piloted aircraft to reach supersonic speeds. A maximum speed of 1700 m.p.h. is claimed for this rocket-propelled project; points of interest apparent in the photograph are the very thin wings and tail-surfaces, and the projectile-shaped fuselage.

In appraising athodyds as a means of aircraft propulsion we have already noted that the thrust varies approximately as (air density)x(velocity)^2. Thus the athodyd is of particular use in giving high thrusts at high speeds when the air drag itself is large. The converse is also true: at low speeds the thrust developed is quite useless, and some auxiliary means of propulsion is necessary to provide for take-off and initial acceleration to a speed of, say, 400 m.p.h., when the duct can itself develop a reasonable thrust. The obvious solution is the rocket which can be jettisoned when expended and so form no further burden to the aircraft.

Obviously a lot of development work will have to be done before athodyds can be regarded as a practical proposition. There seems no doubt, however, that they will supersede the rocket in many applications. On present-day standards it is possible to envisage an interceptor powered by athodyds which could climb to the stratosphere in a matter of 3 minutes, and there have an endurance of 20 minutes at M=0·85, 15 minutes at M=0·9, or about 5 minutes at M=1·2. In considering the relative merits of interceptors the important criterion is *pursuit range*, which is equivalent to the product of the difference of speed between attacking and pursuing aircraft and the latter's endurance. Consider a bomber flying at M=0·8 and the subsonic fighter with a top speed of M=0·85 and an endurance at this speed of 20 minutes; the pursuit range of the fighter is 11 miles. If its speed is stepped up to M=1·2 but its endurance falls to 5 minutes; the pursuit range would nevertheless be increased to 22 miles

As we have seen, however, the athodyd is only really economical at very high supersonic speeds; and the rocket is never a very economical proposition, although it provides an easy solution to the problem of high power at high speeds. Table I below displays the relative performance characteristics of the rocket, the athodyd and the gas-turbine engine.

	Speed of Aircraft	*Rocket*	*Athodyd*	*Gas Turbine*
	m.p.h.			
Weight in pounds of power plant to produce 1000-lb. thrust at 36,000 ft.	600	100	250	300
	1200	100	60	250
	1800	100	25	400
Weight of fuel necessary to produce 1000-lb. thrust for one minute at 36,000 ft.	600	300	100	20
	1200	300	75	30
	1800	300	45	50
Frontal area in sq. ft. of power plant which produces 1000-lb. thrust at 36,000 ft.	600	0·1	3·0	2.0
	1200	0·1	0·75	1·5
	1800	0·1	0·3	2·5

TABLE I.—Variation of Thrust, Fuel Consumption and Frontal Area of various power plants, at various speeds.

Future attempts to design a long duration aircraft to exceed the speed of sound may well be made utilising the gas-turbine engine, suitably modified for the task. It will have to be a very powerful engine installation, the thrust at take-off probably exceeding the weight of the aircraft, although whether a vertical take-off will be employed is a debatable question.

The gas-turbine engine will of course provide jet propulsion, pure and simple, and may well be a sort of compromise between the present-day gas-turbine engine and the athodyd.

Continued on p. 32

Science and Geopolitics

E. M. FRIEDWALD

FEW would dispute the fact that, by reason of its permanence, geography has, throughout the ages, been the most fundamental factor in the political evolution of states and peoples. It is rather the degree to which geography has controlled history, the extent to which it is capable of determining or influencing the policy of states, that can be disputed. But whether one inclines to the thesis of the German school that geography imposes strategic and political inevitabilities—a convenient justification of expansionism—or whether one accepts the view of the French, British and American schools, that geography does no more than offer strategic opportunities and political temptations, there is no denying the reality of geopolitics. Not the peculiar German philosophy which came to be known as geopolitics (a doctrine of *Lebensraum* and unlimited expansionism), but geopolitics proper, which is the study of the interrelation of geography and politics; not a pseudo-science with natural laws and ready-made formulas, but an objective view of possible interactions between geographical conditions and political organisations. In this sense, geopolitics is the use of geography as an aid to statecraft and strategy; it is in fact geographical politics and strategy. And as such it has been effective ever since men combined in the political organisations called states.

How far is geopolitics relevant in the age of the aeroplane, the rocket and the atomic bomb? Nothing can give a better idea of the impact of science and technology on politics than the geopolitical revolution which has been brought about by the stupendous discoveries of our generation. Strategic and political concepts and values built on geographical foundations, which for centuries have dominated the life of nations, have suddenly lost much of their meaning—just how much is not yet clear. They are not made less obsolete by the tenacity with which statesmen and chiefs of staff cling to traditional concepts. In fact, it seems as though geography as a fundamental factor in politics is being superseded by science and technology; as though geopolitics is giving place more and more to what might be called 'technopolitics'. We have reached a stage where science has the power to override geographical realities so far as to become itself a fundamental factor in politics.

The Effects of Early Technology

Now this process is not an entirely new phenomenon. It is the unprecedented pace at which it has proceeded in the course of the last generation that is new—the unprecedented scale on which geographical influences have been overridden, and sometimes even abolished, by the lightning progress of science and technology. But the process itself can be observed throughout history, though at an incomparably slower pace, and on a much less spectacular scale. In a very broad sense, the record of history is one long struggle of man against the forces of nature, the story of man's increasing ability to control the forces of his environment. With every major step in scientific progress and technical advance, man has, as a rule, freed himself a little more from the constraints imposed on him by nature, though there have been exceptions to that rule. The kind and the degree of influence which geographical conditions have exerted on man and the State have at any given time been dependent on the prevailing degree of civilisation; and the degree of civilisation means to a large extent the degree of scientific and technical knowledge.

Primitive man was entirely at the mercy of his environment. He took his first step towards liberating himself from it when he invented tools—the first known manifestation of practical science. He took his next major step when he learned how to produce and control fire. The 'invention' of agriculture must rank as a complete revolution in the relations between man and earth, because it enabled a given piece of land to support a hundred people by agriculture, where before only one could live by hunting. The sea was originally an impassable barrier, until man learned how to construct boats and to sail them and to use the sea as a highway.

The same process can be observed on the level of the early political organisations. For thousands of years Egypt was afforded the protection of the desert, and Babylonia that of swamps. Desert and swamps were an efficient barrier to keep off savages in a primitive age; but they were no obstacles to enemies with a higher civilisation, and Egypt and Babylonia fell when these came—an early illustration of the fact that an ideal 'natural frontier' in one age may lose all its strategic value in another.

The discovery of the metallurgy of iron in the fourteenth century B.C., and the subsequent use of iron tools led directly to the shifting of the centres of civilisation from the sub-tropical to the temperate regions. For the iron axe made it possible to clear the dense forests blocking the Rhone Valley, and thus to open up the one easy way northwards from the Mediterranean.

Roads and wheels were known well before Rome, but it was only the Romans who discovered how to make use of them on a large scale. And the Roman road was fundamentally a scientific remedy for a geopolitical weakness; its purpose was to hold together a whole host of different, widely separated regions.

Again it was scientific and technical progress which made possible the great geopolitical revolution at the turn of the fifteenth century—the discoveries of the New World and of the oneness of the Ocean. For though, as early as the third century B.C., Eratosthenes of Alexandria had recognised that the world was a globe, and had even calculated its size, his discovery could have no practical effect as long as men had not enough technical ability to make use of it. It was only when the mariner's compass, the rudder and improved methods of calculating longitude (based on Muslim astronomy and trigonometry) became available that this knowledge acquired practical value, and eventually led to the discoveries of Columbus and Magellan. These resulted in the shifting of the centre of the world

from the Mediterranean to the Atlantic. Politically, the most momentous consequence of this was the phenomenal rise of England, which, from being on the edge of the world, suddenly found herself in the centre of it.

These few characteristic examples show that, throughout history, scientific progress has resulted either in direct changes in the map of the world, or in changes in the political implications of geography. But the process was so slow and gradual as to pass almost unnoticed, chiefly because major discoveries and inventions capable of fundamentally altering geopolitics were so few and far between. It is only since the Industrial Revolution that the pace of this process has quickened until it has reached the shattering rate of today.

Coal and the Steam Engine

The discovery of the steam-engine and of coal as a source of motive power must rank with those of tools, fire, iron and the ocean as one of the greatest discoveries in the history of mankind. Geopolitically it had fundamental and far-reaching effects, though these began to make themselves felt only when, some two or three generations later, the discovery materialised in the form of steamships, railways and the growth of heavy industry.

As industrialisation became an essential condition of political power, the geographical location of the main raw materials, particularly of coal, assumed a political importance of the first magnitude; and the location of the main coal deposits became a potential centre of political power. It was coal that made the greatness of Britain, Germany and the United States, just as it was the scantiness of coal that, apart from any other factors, made the decline of France inevitable. It is interesting to note that in this case scientific and technical progress resulted in the tightening of the grip of geography on politics; for it brought about a state of affairs where the geographical accident of coal deposits determined to a large extent the political power of nations, while the location of other raw materials affected increasingly the foreign policy of governments. But simultaneously other developments were working to loosen this grip. These were in the realm of communications and transportation.

The railway, in particular, became the ideal instrument of strategic, political and economic policy, a geopolitical tool incomparably more efficient and powerful than the roads had ever been. It was the Trans-Siberian railway, and that alone, that enabled Russia to hold eastern Siberia; just as it was the transcontinental railways which, by preventing the growth of independent republics on the Pacific coast of North America, united the North American States. Again it was the Canadian Pacific Railway that brought British Columbia into the Dominion of Canada. This is only what, on a smaller scale, happened in every major state in Europe. Germany, in particular, planned and developed her railway system with an eye to strategic and political considerations—external as well as internal.

In the realm of sea communications, the piercing of the isthmuses of Suez (1869) and of Panama (1914) were great feats of engineering which, though involving almost imperceptible changes on the map, produced a veritable *volte-face* in global strategy. While the Magellan Straits and the Cape lost much of their importance as nodes of sea traffic, the Mediterranean, which since the discovery of Columbus had ceased to be the centre of the world and become no more than a backwater, suddenly found herself promoted to the position of the lifeline of the British Empire and one of the most important sea-lanes of the world. The opening of the Panama Canal was geopolitically a transformation of the first magnitude because it gave America all the strategic advantages of insularity. On a much smaller scale, the Kiel Canal (1895), though it could not confer insularity on Germany, fulfilled a somewhat similar function by eliminating the strategic disadvantage of two separated coasts.

But there was also ample evidence to show that science would be able to overcome at least some of the limitations of the soil and the subsoil. Investigations of soils and the conditions necessary for the successful cultivation of different crops were beginning to yield remarkable results. Studies of improvement of crops by selection and breeding, of plant diseases and of ways of combating them, and, above all, the use of fertilisers on a large scale, resulted in some spectacular increases in the yield of crops. The sugar content of the beet rose from 3% in about 1800 to 10% in the 1860's and to 15% to 20% in the 1930's. In the fifty years preceding the Second World War the yield per acre of wheat increased by about 60% in Germany and Holland, and by 80% in Yugoslavia. The large-scale use of synthetic fertilisers, made available by the development of the synthesis of ammonia at the beginning of the twentieth century, made possible not only an increase in yield of regions already cultivated, but also the opening of of hitherto sterile lands to crop-bearing.

But synthetic fertilisers were only the first step in the amazing development of synthetic products and other substitutes, a development which has had far-reaching geopolitical implications. These can perhaps best be illustrated by the synthesis of petroleum. As a result of the First World War oil became one of the most important strategic materials, and for years oil politics was at the back of much of the foreign policy of the Great Powers. Though several factors contributed towards the abatement of the 'oil war', the most potent was undoubtedly the industrial realisation of the synthesis of oil from coal in the late 1920's. In the same way the appearance of synthetic rubber, artificial textile fibres, plastics and other substitutes has considerably altered the strategy of raw materials as dictated by geographical considerations. Even the position of coal is bound to be profoundly affected by the discovery of atomic energy. No doubt atomic energy cannot replace coal as a chemical agent, i.e., in the manufacture of pig iron, or as a basic raw material of the chemical industry; but it can replace coal as a source of motive power.* Now, in contrast to coal, the raw materials of atomic energy can be easily transported over any distance. This means that backward countries would be much less dependent for their industrial development on the geographical location of coal deposits than they have been until now—provided that the raw materials of atomic energy are accessible. In this connexion, it may be said that uranium and thorium are found widely distributed all over the globe, though rich deposits seem to be comparatively few. The use of atomic energy for industrial purposes

* The prospects of atomic energy supplanting petroleum are not yet in sight.

might well bring startling changes in the distribution of world industry.

Yet all these developments, however striking they seem, are but minor changes in comparison with the geopolitical upheaval produced by the advent of atomic air power.

The Advent of Air Power

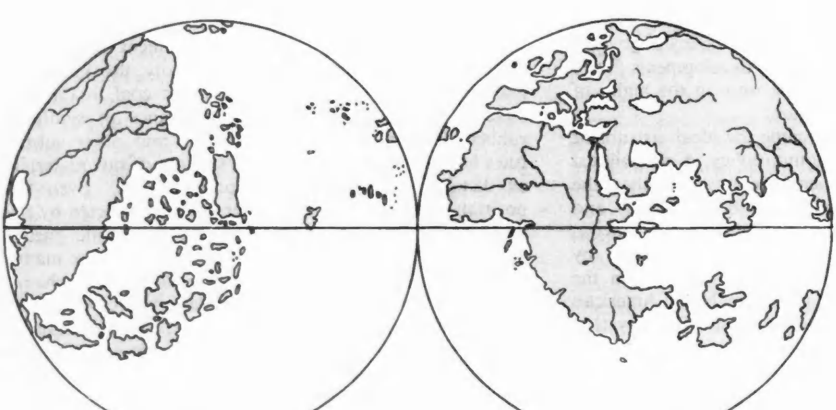
Though the aeroplane first made its appearance at the beginning of the century, it was nearly twenty years before its potential capacity to overcome geographical obstacles was practically realised; and it was nearly another twenty years before the development of aviation reached a stage where the term 'air power' took on a real meaning. For true air power only appeared in the middle of the Second World War. And no sooner had aviation reached that stage than it was rapidly followed by the flying bomb, the stratopheric rocket and, finally, the atomic bomb. Thus one can say that it was not until the second half of the last war that air power as well as atomic power came into being. And it is only the atomic bomb which has given full strategic and political meaning to air power.

The conquest of the atmosphere, revolutionary though it was, had a much greater psychological than material effect. The feeling that distance and geographical barriers counted for nothing weighed more heavily in the minds of men than could be justified by the actual performance of aviation both in peace and in war. For indeed, the destructive power of explosives known before August 6, 1945, was utterly inadequate, or alternatively, aviation had not sufficient carrying power relative to the manpower expended on its construction and operation. For even the biggest 'ships of the air' cannot compare in tonnage with the smaller ships of the sea. How far the possibilities of aviation alone were overestimated is shown by the writing of the Italian general, Douhet, who first laid down the fundamental principles of aerial warfare, and who still remains the only original theorist on the subject. Douhet thought that wars could be won from the air, with the armies and navies playing only a subsidiary part. He believed, for instance, that 1000 tons of explosive, incendiary and poison-gas bombs dropped on Paris or London could destroy those cities, and that such an action would have an incalculable effect upon morale. Today, in the light of war experience, we know that such an effect can be achieved—but only with bomb loads twenty, thirty or forty times as heavy as those given by Douhet. Now even towards the end of the war the heaviest raids did not exceed the 2,500 ton mark—and that at an almost prohibitive cost in men and materials. That is why, notwithstanding popular slogans, aviation by itself did not deprive Britain of her insularity, even though it laid her open to attacks from the air; nor did it render navies obsolete, even though it greatly changed naval strategy.

From the point of view of air power, the flying bomb, and, to an even greater extent, the rocket bomb marked a great advance over the aeroplane, because both meant a considerable economy of manpower. But it was only the discovery of atomic energy which gave to air power its limitless destructive possibilities.

If one had to sum up the geopolitical revolution of today, it could perhaps best be done by saying that the conquest of the air has recast the map of the world, and forced a complete revision of politics and strategy. Political and strategic thinking have for hundreds of years been moulded by a geographical view that is no longer true. We literally did not realise what it meant when we said that the world was round. Until a few years ago, it was the Mercator map, invented in 1569, which dominated the imagination and thought of statesmen and nations. But the Mercator map is no more than a mathematical symbol, and mathematical symbols can be very misleading when read without mathematical knowledge. It shows Greenland larger than South America, whereas actually it is only one-ninth as large. It shows the direct route from Europe to the Far East as eastward; it shows the direct route from New York to China as westward; actually the direct route in both cases is north-south. It is only the Mercator which could create the illusion of the Western and Eastern hemispheres; for San Francisco is nearer to Moscow than it is to Rio de Janeiro, and Chicago is nearer to Constantinople than to Buenos Aires.

But all these truisms have only acquired a practical meaning since the conquest of the air. For in



The World according to Behaim, 1492. Known as the Nuremburg Globe, this map, made on the eve of Columbus's discoveries, was based on Ptolemy's map of the world and the observations of Marco Polo and other travellers. (*After the map in "A History of Geographical Discovery and Exploration", by J. N. L. Baker.*)

a world bound by land and water, the distortions of the Mercator map were relatively unimportant, as many of them corresponded to what was actually possible. Ever since Columbus men have attempted the short cut northward, but have always been thwarted by the ice of the Arctic. The aeroplane, by solving the problem of the northwest passage, has in fact completely upset geography, and therefore geopolitics. Certain regions hitherto almost unknown have acquired a pivotal importance. This is so particularly for Greenland and Iceland, which have suddenly become vital spots on the shortest route between Europe and the eastern part of North America; and of Alaska and the Aleutians, which are on the direct route between the United States and the Far East. Even more striking is the sudden metamorphosis of the Arctic Circle which, from being a region of icy desolation, has become a vital strategic zone. We have suddenly realised that the Arctic Ocean is in fact the mediterranean of the world; around it lie the land masses of Europe, Asia and North America. The shortest flying routes (though not necessarily the most economic from the commercial point of view) between most of the north temperate zone nations cut through the Arctic Circle, and many of them cross the Arctic Mediterranean. Only on the Mercator map does it look reasonable to fly east and west, and to cross the Pacific when travelling between, say, North America and the Far East.

THE PRINCIPAL HEMISPHERE—the hemisphere with the maximum amount of land in it. Ninety-four per cent of all the people on earth and 98% of the world's industry are in this hemisphere. This map derives from the very careful calculations made by A. Penck in 1899. Mackinder's Heartland is cross-hatched. (*See "Geographische Zeitschrift"*, 1899, *Vol.* 5, *pp.* 121–126.)

All this has naturally resulted in a complete reappraisal of world politics in terms of the new geography. It is now realised that American isolationism was fostered by the cartographical isolation of the American continent on the Mercator map. If this isolationism is now dying down, if indeed the United States is for the first time taking a leading part in world politics, it is because under the impact of air power Americans have been forced to relearn geography in terms of the globe, and to realise that, far from being separated by the Atlantic and the Pacific from Europe and Asia, they are in fact next door to them across the Arctic Mediterranean. Important as this realisation was psychologically when air power came into being in the middle of the war, it was only with the advent of the atomic bomb that it acquired its full political meaning.

Ever since the First World War Britain had realised that aviation had changed her situation both in the Mediterranean and in her own islands. The Second World War demonstrated that, in spite of the control of Gibraltar, Malta and Suez, the Mediterranean could be closed to British sea power by hostile air power based on the shores. Gibraltar and Suez no longer served to maintain British communications, but to close the Mediterranean in order to prevent hostile fleets from menacing the Cape route. But as far as Suez is concerned, this function can now be performed by British air power operating from bases other than in Egypt; hence the pending evacuation of Egypt. Until August 6, 1945, Britain still remained an island, though the appearance of the rocket raised serious doubts as to her insularity. The explosion of Hiroshima dispelled all doubt: atomic air power has made insularity a thing of the past. But also it has fundamentally altered the position of Russia as the pivot state in the balance of power as first recognised by Sir Halford J. Mackinder at the beginning of the century.

On January 25, 1904, Mackinder read before the Royal Geographical Society in London a paper, "The Geographical Pivot of History", which was to impregnate all subsequent geopolitical thought. The idea of this geographical pivot was further developed at the end of the First World War in his now famous book *Democratic Ideals and Reality*. He considered that world history was the result of the pressure which the land-locked peoples of the Eurasian plain have exerted throughout the ages on the surrounding peoples of the coast-lands. He thus saw the geographical pivot of history in that largest plain on the face of the globe, which stretches roughly from the Arctic coast to the Central deserts, and from the Yenisei to the broad isthmus between the Baltic and the Black seas.

This plain, the Heartland, is the greatest natural fortress on earth. It contains immense natural resources, it offers ideal conditions for the development of high mobility and, above all, it is inaccessible to sea power for the Baltic and the Black Sea can be closed by land power. Now this Heartland dominates strategically the three continents of Europe, Asia and Africa, which in fact form but one continent, the World Island. The World Island, with the little islets of Britain and Japan, contains fifteen-sixteenths of the population of the globe; in comparison North and South America as well as Australia are mere satellites. Mackinder saw that the oversetting of the balance of power in favour of the Heartland, resulting in its expansion over the coastal lands of Euro-Asia, would provide the widest possible base for sea power, and the empire of the world would then be in sight. This might happen, he thought, if Germany, or a Japanese-organised China, were to ally themselves with, or conquer, the Heartland, because this would add an oceanic frontage to the resources of the great continent. But he considered that Germany, bordering the only open and vulnerable side of the plain, was in by far the best strategic position to conquer the Heartland. Hence the warning addressed to the Versailles peacemakers, emphasising the necessity of protecting a Russia, weakened by war and revolution, from Germany through a tier of independent states. For "who rules eastern Europe commands the Heartland; who rules the Heartland commands the World Island; who rules the World Island commands the world."

This concept became the basis of Haushofer's *Geopolitik*, and dominated the strategic and political thought of the Third Reich. But today the rôles are reversed; Germany alone will never again be able to threaten the Heartland; it is Russia, today the greatest land power in the world, which rules eastern Europe. The Heartland is nearer to the coasts of Euro-Asia than it ever was; and in two of the most important coast-lands, France and China, the Communist parties are the first and the second political parties respectively.

But what is the strategic significance of the Heartland in the era not merely of air power, but of atomic air power?

Commenting in *Foreign Affairs* in July, 1943, on the concept of the Heartland, Mackinder was rather sceptical of changes caused by the dream of a global air power which would liquidate both fleets and armies. He pointed out that "air power depends absolutely on the efficiency of its ground organisation", and that "no proof has yet been presented that air fighting will not follow the long history of all kinds of warfare by presenting alternations of offensive and defensive tactical superiority, meanwhile effecting few permanent changes in strategical conditions." But since then there have been the rocket and the atomic bomb. Atomic air power is very nearly independent of a ground organisation, for one atomic bomb, sent by rocket or by plane, is equivalent to the bomb-load of several hundreds of the largest aeroplanes. And while the possibility cannot be excluded that some defence against atomic air power may be devised in the future, the fact remains that, for the time being, the balance between offence and defence has definitely been upset in favour of the former. Though vast territory may lessen vulnerability to atomic air power, provided that advantage be taken of the space to decentralise industry and essential services.

Thus the Heartland has no longer the same strategic meaning as it had only a few years ago. For today even the greatest 'natural fortress' on earth is vulnerable to atomic air power; and as for vastness of resources, it must be remembered that in our days the most significant resource is scientific capacity and technical ability. The politics of atomic air power have nothing in common with the geopolitics of land and sea power. The real significance of the spread of Russian influence over Germany lies no longer in geopolitics, but in 'technopolitics', in the fact that Germany, despite her depredations, remains a major breeding ground of scientific capacity, technical ability, and organisational efficiency. It is in just these respects that Russia lags far behind the West, and is likely to lag for several generations.

Because of its unique ability to overcome geography, the aeroplane has always carried within itself the germ of a geopolitical revolution. Atomic air power has made this revolution a reality. Science and technology have always tended to loosen the shackles which geography had placed on political actions. Today they have reached a stage where geopolitics, as we have known it, seems to be losing all its meaning. The uneven distribution of fertility and geographical opportunity, which has to a large extent been responsible for the unequal growth of nations, is, under the impact of science, tending to become more even. And science has not said its last word. The greatest advances remain to be made in the equatorial regions which until now have had no history. Already the new insecticides promise to revolutionise life in the tropics; and then there is the prospect, perhaps not so remote, of using directly the energy of solar radiation. In the hot desert of the Sahara, on to an area of one square mile, there is directed each year as much energy as could be obtained from 350,000 tons of coal.

Our view of the world has ceased to be static, and has become dynamic; distances are no longer measured in miles, but in flying time; and science is continually shortening this. Straits, mountains and geographical barriers, in general, have lost much, if not all, of their strategic value. Today we live in a world the farthest point of which can be reached by aeroplane in less than forty-eight hours, and by radio in less than one-tenth of a second. In fact the great geopolitical reality of today is no longer the division of our globe into compartments—be they artificial or natural. Science has made them all into one, even though statesmen and nations may be slow to implement this truth. The only hope is that they will do so before science has made our one world into none.

The new and elaborate calculating machines, miscalled 'electronic brains', are capable of solving many mathematical problems which have long remained unattacked because the calculations they would involve would take too long if attempted by human computers. But further advance in many branches of science awaits the solution of such problems; this is true, for instance, of nuclear physics and aerodynamics. Some of the statistics connected with sociology and economics are also very complicated and have not been analysed mathematically. The new calculating machines are interesting from the point of view of design, and they are of great importance because they promise an early solution to many problems which are as urgent as they are difficult.

ENIAC, ASCC and ACE

MACHINES THAT SOLVE COMPLEX MATHEMATICAL PROBLEMS

S. LILLEY, M.Sc., Ph.D.

PEOPLE who have no actual experience of scientific work usually think of it in terms of its great discoveries, and have very little idea of its long spells of tedious drudgery which are just as important as the occasional moments of inspiration. It is probably in the application of mathematics to scientific problems that this drudgery becomes worst—typically one spends a few days working out the equations whose solution is necessary for the application (usually a very interesting job), another day or so deciding how to calculate numerical results from these equations (a moderately interesting job) and then months and months of tedious arithmetic to compute the results (one of the dullest jobs on earth). Many applications of mathematics which are theoretically possible have hitherto been impossible in practice, simply because the calculations would take years—or even generations—so that, for instance, in aerodynamics it has usually been necessary to perform experimental trials on models, even when the theory which could replace the trials does exist.

In the history of civilisation one of the principal roles of machines has been to abolish many forms of tedious repetitive work. It is therefore natural that for the last 300 years men should have tried repeatedly to evolve machines that would take over the tedium of computation.* But there appears to be one big difference between the mechanisation of mathematics and the familiar type of mechanisation represented by, say, the substitution of a coal-loader for a miner with a shovel—namely that the mathematical machine seems to involve brainwork. This difference has so struck the imagination of many people that the largely automatic machines which have recently been built to perform complex calculations have come to be called 'electronic brains'. However, if we are to avoid falling into the trap of regarding these machines as greater mysteries than they really are, it is necessary to examine just what sort of 'brainwork' they can do, just what functions of the human brain they can take over. In fact, it turns out that these machines are artificial brains to just the same extent, and no more, that a crane is an artificial arm or a railway train is an artificial pair of legs. They can take over any of the calculating functions of the brain which can be foreseen and planned ahead in a routine manner. They can do this no matter how long and complicated the routine (though there are limitations in practice), but they cannot deal with any situation requiring a judgment which has not been foreseen by the human brain which set the machine going—just as even the most automatic railway requires the intervention of a signalman whenever anything occurs that has not been planned as part of its routine operation.

Let us see what is required of an automatic calculating machine, by considering the steps involved in carrying out a simple calculation. Suppose a computer is given two numbers to start with and told to carry out the following calculations: *Multiply the two numbers together, obtaining one new number; also add them together, obtaining another new number. Now take the two new numbers and, starting with them, repeat the original processes, obtaining two further numbers. Repeat the process on these. And so on.* (This example is of no practical importance, but does illustrate in very simplified form many of the features which do occur in practical cases.)

If the two numbers originally given were *1* and *2*, the the successive new pairs obtained would be those printed in the successive columns of the table:

1	*2*	*6*	*30*	*330*	*13,530*	*5,019,630*	*69,777,876,630*	. . . .
2	*3*	*5*	*11*	*41*	*371*	*13,901*	*5,033,531*	. . . .

Incidentally, this example illustrates how complicated can be the arithmetic arising from a problem whose formulation is very simple. And the problems that actually arise in practice are very much more complicated.

Now let us note what a computer, unaided by machine, must be able to do in order to solve this problem.

1. He must have a memory capacity. At least he must remember the two numbers in the last computed column until he has calculated those for the next column; it may also be necessary to remember some or all of the numbers till the end of the whole calculation, since these may be among the results that are finally required. In practice, the memory usually takes the form of writing the results on paper in a systematic way. An automatic machine must replace this with some mechanical or electrical device which can be put in a particular state to represent each number, which will stay in that state as long as required, and which finally, on receiving a given signal, will send its contents to some other part of the machine where they are to be used.

*See "Machinery in Mathematics", by S. Lilley, in DISCOVERY Vol. 6 (1945), pp. 150-6, pp. 182-5 for the history of these machines and also of Babbage's proposal.

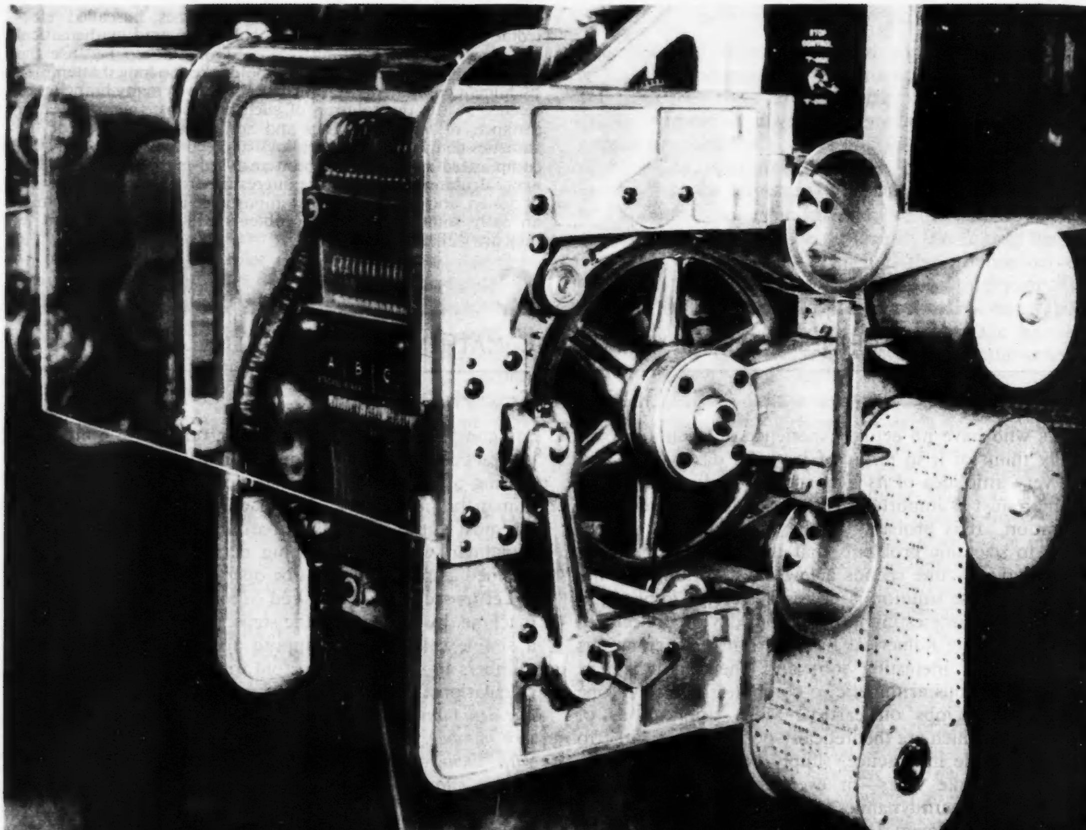


FIG. 1.—Sequence control mechanism of the Automatic Sequence Controlled Calculator.

2. He must know his tables of addition, subtraction, multiplication and division. The machine must replace these faculties by suitable mechanical or electrical devices—for example, a toothed wheel which can be turned round so many teeth for one number and so many more for another, forms the basis of one form of adding unit. (See figs 3 and 4 in the "Machinery in Mathematics" article, DISCOVERY, 1945, pp. 150-6.)
3. He must know and use a set of rules which tell him what to do next with the numbers he has before him. This includes the rules that tell him how to use the results of his multiplication table, for example, in order to do the complete multiplication of numbers involving several digits. Since the nineteenth century, practicable machines have been available which can take over from him responsibility for this part of the rules, but there remain those rules which are set out in the statement of the problem and which can be put in the form: *take the numbers which are written in such-and-such places, do such-and-such an operation on them, and write the result in such-and-such a place.* If the reader will take the numerical example given above and put its rules in this form, making sure that the instructions to the computer are absolutely unambiguous, he will see how much of this working to rule the human computer normally takes unthinkingly in his stride. The mechanisation of this side of computation is in fact the key to the new automatic machines.
4. The computer has a further responsibility when the statement of the problem is that a particular set of rules are to be followed only up to a certain stage, and then a different set of rules are to be substituted for them. For instance, it might be specified that the calculations of the above example are to be continued until one number is more than 10,000 times the other—this ratio has been reached in the last column of the table, as becomes obvious if you divide the upper number of the last column by the lower number; thereafter the calculation is to follow the new rule, *Put in the next column (a) the lesser of the numbers in the last column calculated, and (b) the result of dividing the greater by the lesser and neglecting the remainder.* In that case the further calculation would proceed:

5,033,531	*13,862*	*363 . . . .*
13,862	*363*	*38 . . . .*

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calculation to another can usually be made to depend on observing whether one number is *greater than*, *equal to* or *less than* another, and it is not difficult to design machine units which will do this.

5. The computer has also to be able in many calculations to perform the function of using tables, that is of finding one number in a list and extracting and using another number placed beside it. It is again not difficult to design units in a machine which will take over the job.

In all this it is easy to see that there are two classes of brainwork involved. What we may call *first-class* brainwork, involving really creative thinking, includes the preparation of the original tables for addition, subtraction, multiplication and division; but this job, of course, has been done once and for all. But the most important part of the first-class brainwork is concerned with formulating the rules according to which the calculation is to proceed —rules which will enable the computer to decide at every stage of the calculation which numbers are to be operated on, what operations are to be performed on them, where the results are to be stored and so on. This also includes specifying the circumstances in which one set of calculating rules is to be replaced by another.

Second-Class Brainwork

On the other hand, second-class brainwork is involved in applying these rules—picking out the particular numbers according to the general rules, subjecting them to the specified operations, storing them (e.g., writing them down on paper) in the places indicated by the rules, and so on. All this bears a very close resemblance to the automatic responses which an unthinking organism makes to its environment. To any pattern on the paper in front of the computer there is one and only one correct response, which can be made by automatic application of the rules. In fact most computers find that after working on a particular computation for some time, their actions become very like conditioned reflexes. This second-class brainwork is certainly brainwork in the physiological sense that the brain is involved. But it is quite as automatic in kind (though more complicated in degree) as tightening bolts at a conveyor belt—and quite as tedious.

What these new machines do is to take over all the *second-class* brainwork. They provide various units in which operations like adding, or storing a number till needed, or comparing the sizes of two numbers, can be performed when appropriate instructions are received. And they provide channels of communication which can be arranged to transmit numbers or instructions from one unit to another. But it is still a human job to decide the rules of the calculation, and to arrange the channels of communication in such a way that each unit gets its raw materials and instructions at the appropriate stage. There is, in fact, some analogy with a factory in which every department does its particular job automatically when supplied with its raw materials and a coded note of instructions, but in which the manager has to plan and organise the system of communications; when a department has finished a job, it puts the piece of work in a shute marked 'Out', but only the behind-the-scenes machinations of the manager can decide which shall be the department to receive the material the shute delivers.

Machines to perform the processes of addition, subtraction, multiplication and division were developed from 1642 onwards and reached a really practical form in the nineteenth century. But these, of course, left the computer to do all the rest of the second-class brainwork. The first proposal to build an automatic machine which would take over this work, was that of Charles Babbage in 1833. His machine was never completed, but its plans did involve all the principles which the recent successful machines employ, except, of course, that it was entirely mechanical, whereas its modern counterparts are partly or wholly electrical. Among other things, Babbage introduced the punch-card method of feeding the machine with numbers and instructions, which is extensively used in modern machines. In this method a series of cards are punched with holes which represent, according to a prearranged code, the required numbers or instructions. These are fed into the machine, and mechanical or electrical 'feelers' detect the holes and transmit the appropriate instructions to other parts of the machine.

Automatic Sequence Controlled Calculator

After Babbage, no notable attempt was made to construct such machines until just before the recent war, when work was begun on the Automatic Sequence Controlled Calculator (ASCC), which has been in operation since May 1944, at Harvard University.

This machine, which normally deals with numbers containing up to twenty-three digits, has seventy-two adding mechanisms, which also act as storage or memory units. Each of these may, of course, contain different numbers at different stages of the calculation. There are also sixty further units which can store constant numbers set manually by switches. There are units which multiply and divide, units which correspond to tables of $\log_{10} x$ and $\sin x$, and units which perform interpolations. The results may be printed by two automatic typewriters, or they may be recorded by punching on cards. There is also a unit feeding the machine with data previously punched on cards; these data may perhaps have been punched by the machine during an earlier calculation. All these units are of an electro-mechanical nature.

Most of these units taken separately are very little more complicated than the ordinary calculating machines which have been familiar for decades. The complication which leads to the automatic nature of ASCC, begins with the mode of connexion by which the various units pass their results to one another or receive instructions as to what they are to do next. The 'messages' are sent in the form of timed electrical pulses, and the operation of the whole system of connexions is rather like that of an automatic telephone exchange. Lastly, there is the control system which forms the key to the whole machine. The instructions to all the parts of the machine, instructions which tell each unit to act in a particular way at a particular time, are translated by a code into rows of holes punched in a tape, as in Fig. 1. This tape is fed past a set of electrical contacts which detect the holes and send electrical impulses bearing the appropriate instructions to all parts of the machine.

The key to the operation of ASCC for any particular problem lies in the punching of the control tape, and also in a long preliminary process of setting switches and making

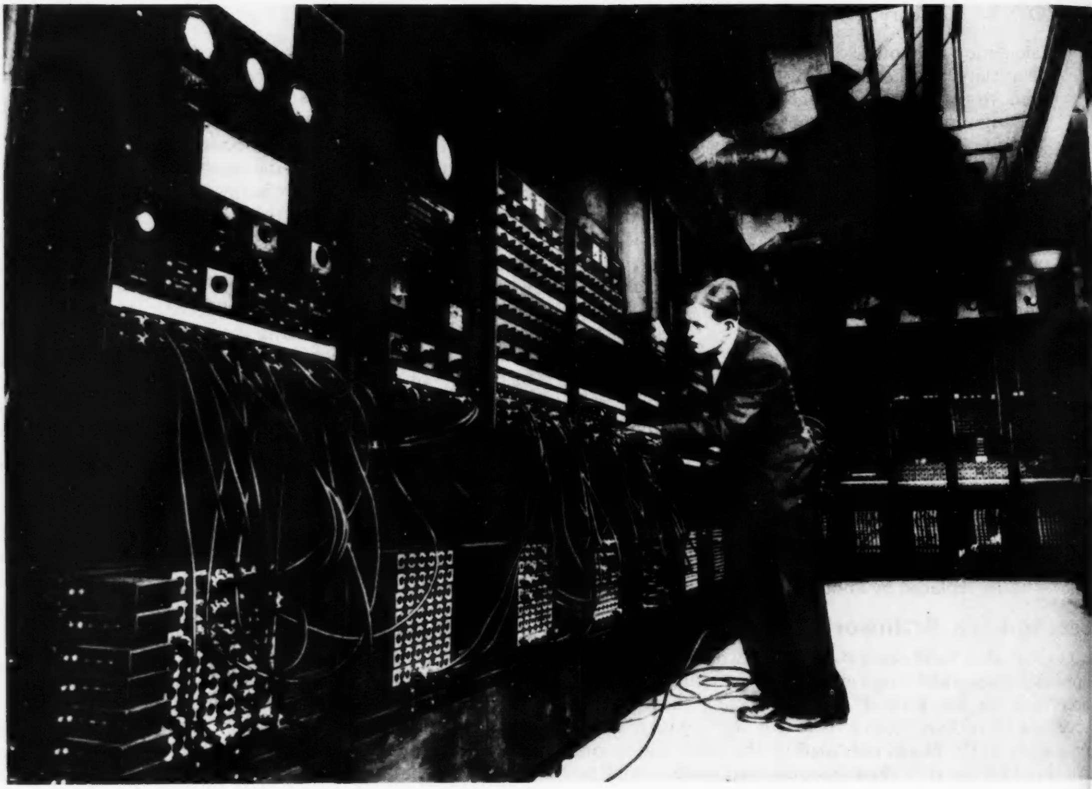

FIG. 2.—A research engineer is seen setting up one of ENIAC's thirty-six units.

plug-in connexions, which we have no room to describe here. Every time the same set of operations is to be performed (as in calculating the successive columns in the example given at the beginning of this article), the same code of punched holes is required on the control tape, so that this is simply made in the form of an endless band which will repeat the instructions as often as required.

The speed of this machine is not spectacular, being limited by its electro-mechanical nature. In the worst possible circumstances and when working with numbers of twenty-three digits, addition takes about one-third of a second, multiplication about six seconds, division nearly twelve, and the calculation of a logarithm rather over a minute. Nevertheless this means in practice that the machine can work about 100 times as fast as a manual computer using an ordinary calculating machine. Furthermore, apart from breakdowns, which are not very frequent, the machine never gets tired or bored, whereas it is a very enthusiastic computer who can do six hours' good work a day. Thus overall the machine can do the equivalent of six months' manual computing in one twenty-four hour day.

Electronic Numerical Integrator & Computer

Most of the detailed operations of ASCC are carried out by opening and closing switches in electrical circuits. The switches are mechanical and are operated by electrical relays. In this electronic age it is a natural next step to substitute thermionic valves for these switches, and that in fact is the step taken by the Electronic Numerical Integrator and Computer (ENIAC) recently put into operation at the University of Pennsylvania. In many other respects this machine differs from ASCC—for example, the control which determines the order of operations in is this case effected not by a punched tape, but mainly by the actual connexions previously set up between the units (and this setting up process appears generally to be the longest part of any computation). But this and many other differences are really secondary features of design, and the fundamental change is that of substituting valves for relay-operated switches. (Figs. 2–5.)

ENIAC uses 17,000 valves, of an ordinary standard type, and none of its main functions is performed mechanically. Since a beam of electrons can be switched on and off far more quickly than a mechanical relay, its speed of operation is far and away greater than that of ASCC. Addition requires two ten-thousandths of a second and multiplication just under three thousandths of a second, when operating with the largest possible numbers—in this case numbers of no more than ten digits. Thus if this machine were set to calculate the first *million* columns in the example given earlier, it would complete the job in well under the hour! The non-mathematical reader should perhaps be told that the limitation of the number of digits does not restrict the size of the numbers with which a machine can deal, but only limits the accuracy with

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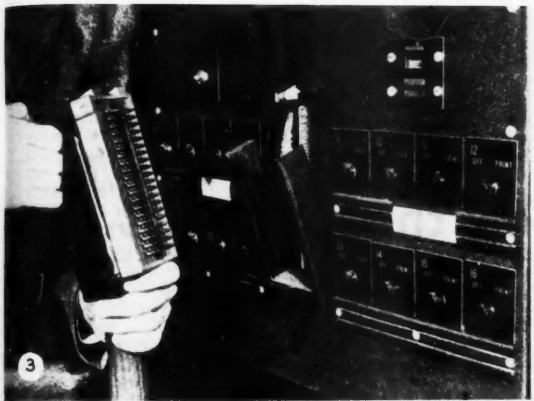
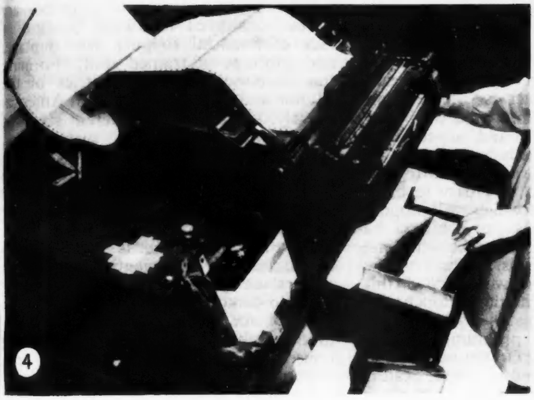




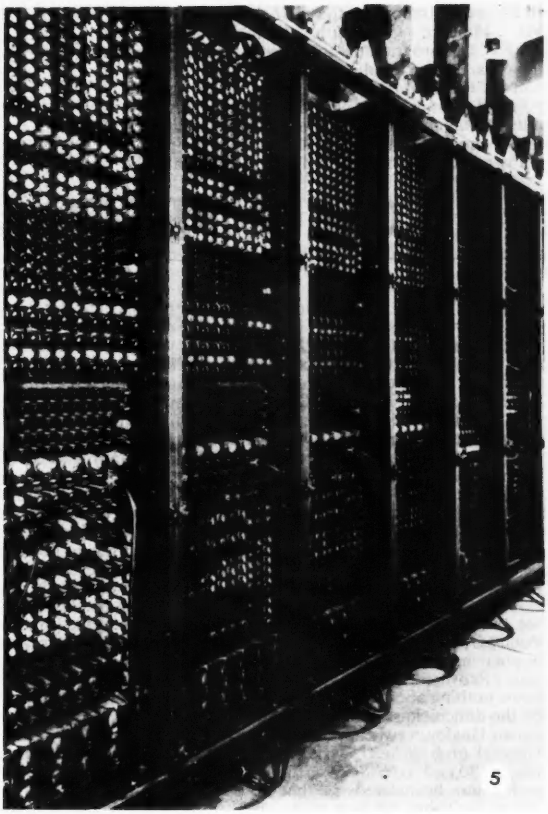


FIG. 3.—The device on the left punches on cards the results of the mathematical treatments that the machine has carried out. FIG. 4.—This tabulating machine decodes the results from the punched cards and prints them. FIG. 5.—Some of ENIAC's 17,000 valves.

which it can represent them; thus with only ten digits, the machine would give the number *60,325,876,942,173* as *6,032,587,694* multiplied by *10,000*, and the odd *2,173* does not usually matter in practice.

When such speeds become available for the generality of practical mathematical problems, the relations between mathematics and its applications will be entirely changed. ENIAC has, however, severe limitations which would make it unsuitable for a large proportion of practical problems. It was built for solving problems connected with ballistics, and though it can go far beyond these, nevertheless its design was limited by the problems in view. In particular its memory capacity amounts to a mere twenty ten-figure numbers, which is hopelessly inadequate for many purposes. (Its memory can be augmented by the use of punch-cards, but this slows down its operation about as much as the operation of the man-in-the-street would be slowed down if his memory consisted in looking up everything in the British Museum.)

Automatic Computing Engine

Since Babbage's time, this story as told here has been entirely an American one, but a recent announcement by the Department of Scientific and Industrial Research gives hope that Britain is about to take a leading position. The DSIR is planning the construction of an even more advanced machine, the Automatic Computing Engine (ACE), which is to cost from £100,000 to £125,000. Mr. J. R. Womersley, head of the National Physical Laboratory's mathematics division, is in charge of the project; Sir Charles Darwin and Dr. A. M. Turing are participating in it, and Prof. D. R. Hartree is advising. Like ENIAC this will work electronically, but it will not have ENIAC's limitations. Its memory, for instance, will be able to carry 75,000 digits. It will eliminate all the tedious switching and plugging which are necessary preliminaries of any computation on ASCC or ENIAC. Instead ACE will be prepared for any computation by the simple process of passing through it a pack of punched cards, and the instructions indicated by these cards will do all the setting up of the machine. (Of course, the punching of the cards will take time; but that can be done while the machine is working on other problems, and, if necessary, many sets of cards can be punched independently.)

At the speeds at which ACE will work, the planning of each computation and the preparation of the cards which convey instructions to the machine will be far more important as regards time taken than the calculation itself. Thus the DSIR team is having to give much attention to these planning problems. It will have to accumulate a library of sets of instructions for standard computations,

[*Concluded on p. 32*

In his second report on the *UNESCO* conference, Mr. Maurice Goldsmith discusses critically *UNESCO*'s programme and stresses the need for the organisation to adjust its aim if it is to achieve success. While Mr. Goldsmith's views on certain points do not coincide with our own, we feel they must be taken into consideration, particularly by those who work at UNESCO House, if the paper plans are to be translated into practical realities.

Can *UNESCO* see the Ground?

MAURICE GOLDSMITH

LAST MONTH, writing from Paris on the day that the first annual conference of *UNESCO* (United Nations Educational Scientific and Cultural Organisation) began with a colourful ceremonial opening at the Sorbonne, I was unable to do more than give an outline of the kind of project which the temporary secretariat had drawn up. Now, after three weeks of listening to speeches, attending meetings, and sounding private opinions, I feel that there are some things that must be said—because I believe that *UNESCO* has a useful function to perform.

After the conference had been in session for twelve days, the French Institute of Public Opinion investigated the degree of popular acquaintance with *UNESCO*. It was discovered that 85% of the people knew nothing about it. This is a measure of the difficult task that lies ahead of Dr. Julian Huxley, newly appointed Director-General of *UNESCO*. His fundamental job is "to sell *UNESCO* to the public", and unless he succeeds in that he might just as well shut up shop now.

The general impression outside of the imposing many-roomed UNESCO House—formerly, as the Majestic Hotel, headquarters of the Nazi rulers of Paris—is that this new organisation is merely another gathering of intellectuals. Perhaps it will do some good work? who knows? Anyway, as Professor Georges Teissier, Director of the Centre National de la Recherche Scientifique, put it to me, we will wait and see.

This is the basic task: to bring the work of *UNESCO* into the common, ordinary, everyday experience of the people. Organisationally, the links do not yet exist.

I believe it to be essential that all persons working under Dr. Huxley should be progressive in their outlook, not necessarily in a political sense. They should want to work for *UNESCO* because—in Huxley's own words—they want to serve the interests of humanity. That is, the person responsible for selecting personnel must himself have a broad vision. Further, the individual responsible for the external relations of *UNESCO* with international bodies must also be of this category.

Important, too, is *UNESCO*'s information service, through which the world is told what is being done. As organised at present it is not good enough. During the period of the conference the Press service failed badly. Together with a representative of *The Times* and the Dutch paper, *Het Parole*, I had to complain to Dr. Huxley. Some of our suggestions were adopted, but the generally poor Press that *UNESCO* received in almost all countries can in some measure be attributed to the visionless Press directors.

Within *UNESCO*, therefore, Dr. Huxley must see that his own spirit is all-pervasive. He must by some means ensure that his bureaucrats—whose salaries are enormous as compared with what the French professor and academician whom they meet socially are getting—do not traditionally cling to the job for the job's sake. It will be very easy to build up a vested interest which will oppose new ideas and methods.

These are some of the key internal administrative problems. What of the actual programme of work? Will this bring *UNESCO* into the closest touch with the people?

I have studied the programmes of all the commissions. By far the best is that of the Natural Sciences, at whose head is Dr. Joseph Needham. But even this has that air of unreality which comes from failing to recognise that internationalism cannot develop without fostering national cultures.

The tasks and functions of the Division of Natural Sciences appear in the booklet "Science and *UNESCO*". A distinction is drawn between temporary and permanent aims. The temporary aim, an immediate aim with which there can be no disagreement, is to assist the restoration of scientific facilities in the war-damaged countries.

The permanent long-range projects are:

1. To throw a network of regional science co-operation stations round the world.
2. To support and extend the international scientific unions and their work.
3. To organise and operate an international Science Service system.
4. To co-operate with the work of UNO and its other specialised agencies.
5. To inform the people of all countries on international implications of scientific discoveries.
6. To originate new forms of international scientific co-operation (e.g. international laboratories and observatories, etc.).

A distinction is drawn between what is termed the 'bright zone' and the 'periphery'. The former, in which all the sciences are relatively advanced and industrialisation is highly developed, covers North America and most of Europe. Large sections of it—Italy, Austria, Germany, South-Eastern Europe—are today in such a state that they are to be considered backward because of lack of financial support, war damage, and shortage of trained staff. Forming the periphery are the countries of the Middle and Far East and South America. Clearly, because of the different stages of development reached in these zones, different treatment is necessary.

Having said all that, I do not think we have advanced very far in the fundamental job of bringing science and technology to the aid of man in his daily struggle. The programme needs recasting to emphasise how the scientist can help to solve these typically urgent social problems, to demonstrate the part science has to play, for instance, in increasing the food supply, in building and improving houses, in developing a health system and in increasing national productivity.

These are universal needs which have to be solved at different levels for different countries. But in so far as the scientists concern themselves with them, to that extent *UNESCO* will receive the support of the masses.

Much play is being made of the proposal to set up new international laboratories. But why consider the building of such laboratories as something immediately important at the present time when in Yugoslavia bridges are urgently needed, and in India agricultural techniques are still terribly poor? Top-notch scientists will have to be found to work at these stations. Will they come entirely from Western countries? If not, will they be provided by the technically backward countries; and if so, will not this deprive these countries of vitally needed technicians? The tendency clearly will be for these stations to be serviced by second-rate men from the 'bright zone' and first-rate men from the 'periphery': and that is the kind of thing that we must avoid. The job of the Division of Natural Sciences is to foster science in the service of the national needs of the people.

There is another point of importance. I do not wish to be dogmatic about this, but is it necessarily a sign of progress to bring a scientist from an industrially backward country to, say, England for special training? The level at which pure science can be studied in this country may tend to uproot the foreign scientist when he returns home—as has happened to many scientists from the Far Eastern

countries. Economically his country has not reached the stage at which the type of research he has been doing is needed and therefore it is unlikely to pay for it.

It follows from this that in the 'periphery' it is the engineer or food expert who will be made more welcome than the pure scientist. And that is as it should be.

When I turn to the programme of the Division of Social Sciences I feel that here is the unreal kind of internationalism. Here is a report of an afternoon session —a verbatim statement of *UNESCO* Press Release 45; the reader's own reaction to it makes any comment from me unnecessary.

"Projects A (International Organisations—collaboration with the promotion of voluntary international organisations in the various social sciences) and B (Survey of Research Resources—publication of a world inventory of research resources in the social sciences) having been adopted this morning, the sub-commission went on to adopt C—the compilation of a Year Book of the Social Sciences which would contain an appraisal of the year's work in the various fields.

"Project D was amended at the proposal of the Australian delegate so that it now provides that an exploration should be made of the problems of setting up an abstracting and bibliographical service covering those social sciences for which no such service at present exists.

"Project E—the study of the means available for writing a Social and Economic History of the Second World War was postponed.

"Project F—the setting up of an international centre to serve as a clearing-house for experiments in the field of Home and Community planning—was referred to the Economic and Social Council of the United Nations.

"Project G—the analysis of Nazi psycho-political techniques was not to be begun in 1947.

"Project H—the creation of a study centre for international relations was under discussion when the sub-commission rose this evening.

"In the debate on Project D, Dr. Mills (South Africa) stressed the importance of the proposal. He said that during the war research had been carried on in his country, and afterwards they found that the same work had also been done elsewhere. The same sort of duplication might go on in peace-time if research workers did not know what their colleagues were doing.

"The sub-commission came to the conclusion that it would be some time before anything could be done.

"In the debate on Home and Community Planning, Professor Holford of the British Ministry of Town and Country Planning took part, and the U.S. delegate, Miss Louise Wright, urged that they should also include the development of river authorities—on the lines of the Tennessee Valley Authority. It was decided that *UNESCO* ask the Economic and Social Council whether it should continue investigations on the subject of home and country planning.

"Sir Alfred Zimmern introduced the proposal for an international study centre (Project H). He suggested that there should be three sample schools held on a campus belonging to *UNESCO*—for teachers, university graduates and undergraduates, and for adults who had not had a university education. The British and American delegates, Miss Margaret Read and Miss Wright, suggested the holding of a conference to study the problem."

I have no space left to examine critically the other Divisions: but, equally, the programme of each needs revising to bring it down to solid earth.

No mention is made in any *UNESCO* documents of Fascism and the need to fight against it. This is a strange omission which has not gone unnoticed, particularly by the East European countries. As M. Vladislav Ribnikar, of Yugoslavia, put it: "If we wish to preserve and consolidate peace, we should fight for peace as we fought the enemies of democracy, as we should protect the latter against the attacks of Fascist and pro-Fascist forces. Our opinion is that *UNESCO* should in no case assist forces whose activity consistently opposes peace and democracy; otherwise *UNESCO*, sooner or later, will place certain democratic countries, members of the organisation, in a position where they will be obliged to reject or not to execute recommendations made by the organisation."

Yugoslavia was regarded as expressing the point of view of the Soviet Union, whose absence was regretted generally. Indeed, Dr. Huxley must attempt straightway to obtain Russia's full co-operation: *UNESCO* without the USSR is as incomplete as would be the United Nations without her.

I have deliberately been highly critical because I believe in *UNESCO*. What I have said above is an attempt by a biased outsider to throw a spotlight on certain things that have been ignored—in the main because the intellectual has been too busy talking of international co-operation to understand that he must have his feet firmly on solid earth among ordinary people if *UNESCO* to is succeed.

Far and Near

Atomic Scientists Seek Public Support

THE Atomic Scientists' Association, which has among its aims the enlightenment of public opinion in this country on the dangers and prospects of Atomic Energy and to press for effective control, is appealing for public support and invites sympathisers to become Associate Members. It is hoped that these new members will assist the work of the association by supporting its aims locally and by their financial contributions. There is a minimum annual subscription of one guinea, but larger subscriptions are invited. Associate members will receive all publications of the association, including the monthly news-letter issued to full members. Inquiries about Associate membership should be sent to Dr. G. O. Jones, Associate Membership Secretary, Atomic Scientists' Association, The Clarendon Laboratory, Oxford.

An Atomic Exhibition

AN atomic exhibition opens in London on January 23. Organised by the *Daily Express*, the exhibition is housed at Dorland Hall, Lower Regent Street, London, W.1. We were given an opportunity of seeing the designs and several models made for this exhibition and these promise that the exhibition will prove a very worthwhile attempt to bring home to the public as vividly as possible the full implications of the release of atomic energy.

Scientific Liaison for the Empire

WITH the increasing demands made upon scientists has come a recognition that there are insufficient scientists to go round and steps are now taken being to train more scientists. This is true of the British Commonwealth as a whole, and the pressing social need of the Commonwealth for the maximum utilisation of scientific knowledge at a time when there are not enough scientists to go round has forced a realisation that available personnel must be employed with the greatest possible efficiency. Such was the background of the Empire Scientific Conference organised by the Royal Society last summer (a report of it appeared in DISCOVERY in August 1946, pp. 254-255) and of the British Commonwealth Scientific Conference, held immediately afterwards. The latter conference, which the scientists attended as delegates of Commonwealth Governments, was not a public conference and the official report of the conference published by the Stationery Office has only just appeared (Cmd. 6970, price 1*s*. 3*d*.).

"I believe that this conference will inaugurate a new era in Commonwealth scientific co-operation, for not only have we decided upon numerous specific recommendations to that end, but we have also set up a permanent machinery both to implement those recommendations and to deal with any similar proposals that may emerge in the future." So said Sir Edward Appleton who presided over the conference. Study of the report shows that the conference used its time well, concentrated on practical aspects of urgent problems, and made realistic recommendations which stand a good chance of early implementation.

The conference provided a nucleus for Commonwealth scientific co-operation by appointing a Standing Committee. This consists of the executive heads of industrial and scientific, agricultural and medical research in Britain, the Dominions and India, together with three representatives of the Colonies. The chairman of the Standing Committee presides over a Working Party which has an office in London in the D.S.I.R. building.

An Empire G.H.Q. for science was advocated at the Royal Society's Empire Scientific Conference, and this proposal found ready acceptance at the official conference. A British Commonwealth Scientific Office is to be set up in London. It will follow the pattern of the liaison office at Washington which under Dr. Alexander King's direction served the needs of the Empire so well in the recent war. The B.C.S.O. will be housed by the Department of Scientific and Industrial Research, which will provide the essential common services, such as a library, and abstracting, indexing and microfilming facilities. Dominion scientific missions and officers in London will thus be brought under one roof, an arrangement that will simplify the mechanics of co-operation, though full autonomy and responsibility to their own governments will be retained. It was recommended that the Washington office should be retained, to provide liaison with the whole of North America.

Many research projects involving Empire-wide co-operation were proposed, as for instance a greatly expanded programme of cosmic-ray research to cost £25,000. Some of the other projected schemes were: an Empire network of meteorological stations and ionospheric recording stations; climatological laboratories (one is already being established at Singapore); a survey of Empire mineral resources; long-term research on fisheries and oceanography; a central collection of type cultures for microbiological investigations.

The resolutions passed at the Royal Society's conference are appended to the report.

Last July the Imperial Agricultural Bureaux also held a conference, and the report of its proceedings has now been published (Cmd. 6971, 1*s.* 3*d.*).

New Journal for General Microbiology

THIS month the Cambridge University Press is publishing for the newly founded Society for General Microbiology the first number of the *Journal of General Microbiology*. The editorial board consists of Dr. B. C. J. G. Knight, Dr. A. A. Miles, Dr. G. C. Ainsworth, Professor W. B. Brierley, Dr. T. Gibson, Dr. A. T. R. Mattick, Dr. Kenneth Smith, Dr. A. W. Stableforth and Dr. D. D. Woods. The object of the Journal is to publish original research work in the field of general microbiology, covering bacteria, microfungi, microscopic algae, protozoa and viruses.

The Journal will consist of three numbers in 1947; it is hoped to increase that number later. The subscription is 50*s.* a year. Editorial communications should be sent to Dr. A. A. Miles, National Institute for Medical Research, Hampstead, London, N.W.3; all other communications should be addressed to the Cambridge University Press, Bentley House, 200 Euston Road, London, N.W.1.

Ministry of Supply's Chief Scientist

SIR BEN LOCKSPEISER has been appointed Chief Scientist to the Ministry of Supply. This newly created post is a continuation of the co-ordination of the research and development programmes for Defence and Air resulting from the merger earlier this year of the Ministry of Supply and the Ministry of Aircraft Production.

Sir Ben will be responsible for co-ordinating research work on the Ministry's military and aeronautical programmes. He will be assisted in these duties by the Scientific Co-ordinating Board, of which Professor Sir John Lennard Jones is chairman. Sir Ben has been prominent in the field of aeronautical research not only at the Ministry of Supply, where at present he is Director-General of Scientific Research (Air), but also at the Air Ministry and Ministry of Aircraft Production. Prior to the war he was head of the Air Defence Department of the Royal Aircraft Establishment at Farnborough.

Exchange of German Technical Data

A NEW arrangement for the exchange of German technical information acquired since the end of the war has been made between the British Board of Trade and the U.S. Department of Commerce.

Hundreds of thousands of important German scientific and technical documents discovered by British and American investigators in their respective zones were photographed. Heretofore the exchange of these documents has been imperfect; but under the present agreement representatives of each nation will be able to select from the other's store the items that they find valuable. In London the main centre for German documents is the Board of Trade German Division (documents unit) at Lansdowne House.

New Fire Research Station

THE Department of Scientific and Industrial Research is establishing jointly with the Fire Offices' Committee (an association of fire insurance companies) a Fire Research Organisation. This will have its own laboratories, but until these are set up the Organisation will use the Fire Testing Station at Elstree which the Fire Offices' Committee has transferred to the Government. The capital cost of the new research station is likely to be of the order of £100,000, with an annual running cost of up to £50,000.

Science on the Air

THE producer now responsible for *Science Survey* is Dr. Archie Clow, and not Mr. J. K. Rickard as was stated, on the authority of the B.B.C. press office, in a recent issue of DISCOVERY. Dr. Clow has produced many science programmes which have proved conspicuously successful in the Forces Educational Broadcasts. In our next issue we hope to carry an article by Dr. Clow dealing with science broadcasting to the Services.

The programme *Your Questions Answered* was distinguished for the high proportion of scientific questions which it dealt with, and gained a high reputation for the straightforward and clear manner in which the questions were answered and for the fact that the feature was always good 'radio'. Successor to *Your Questions Answered* is *Observation Post*, the first number of which was heard on January 3. Science is to have an equally prominent place in this programme which will have a greater scope than its predecessor. Listeners are not invited to submit questions, but comments and suggestions are welcome, we gather.

"DISCOVERY" INDEX

The index to Volume VII of DISCOVERY will be published with our next issue.

Sources of Chemicals

THE Association of British Chemical Manufacturers has published a directory of chemical manufacturers entitled *British Chemicals and their Manufacturers*. The volume which is indexed both for names of substances and their trade names gives up-to-date information about the manufacturers of all types of chemicals, heavy, fine, pure, etc. A free copy will be sent to any bona fide inquirer. The address of the Association is 166 Piccadilly, London, W.1.

Death of Langevin

THE death occurred on December 19 of PROFESSOR PAUL LANGEVIN, the French physicist, at the age of 74. He was director of the Ecole de Physique et de Chimie Industrielle in Paris, which he entered as a 16-year-old student. He served his apprenticeship to research under J. J. Thomson, and afterwards under the Curies. A very versatile scientist, he made additions to knowledge in many branches of physics, including radioactivity, the study of X-rays and fundamental particles. The technique whereby very low temperatures are reached by demagnetisation was developed from one of Langevin's ideas. Supersonic waves were discovered by him.

In the second World War he was the first prominent French scientist to be sent to a German concentration camp, but he was released after world-wide protests had been made.

His position as a leader of French science can be appreciated from the frequency with which his advice was sought, and not only by scientists; in the last two years, for instance, he was appointed by the French Government as chairman of an educational reform commission, an adviser to the Commissariat for Atomic Energy and deputy chief delegate of France to the *UNESCO* conference.

Photography and Nuclear Research

A ROYAL PHOTOGRAPHIC SOCIETY lecture on "Photographic Methods in Nuclear Research" was given recently by Dr. C. F. Powell of Bristol University.

Atomic physics, the lecturer said, has two main basic purposes: the production of particles and their detection. In the latter field, the photographic plate provides one of the most promising methods. The photographic material excels all other methods by the fact that it is always ready to take a record and will continue to do so over a long period of time. Furthermore, it can distinguish the various particles passing through it by virtue of the fact that the density of grains on the track differs. The new plates produced by Ilford Ltd., were described. These emulsions are characterised by a high silver halide-gelatine ratio. This means that the natural variation in length of the track was now the only limiting factor in the determination of the range of atomic particles.

The lecturer then dealt with various applications such as the measurement of the natural radioactivity of minerals and of the energy of fast neutrons, the scattering of fast protons and deuterons produced in a cyclotron, and the effect of cosmic rays. Methods were now being developed which would allow an exposed and processed plate to be scanned rapidly and conveniently by an unskilled observer. In order to achieve its full value, the photographic method must be developed so that unskilled observers can be freely used.

In closing, the lecturer suggested that the widespread popular interest in atomic physics and the ease of the photographic method indicated that atomic physics would be a suitable subject to form a basis for special clubs run along similar lines to amateur astronomical societies. He, personally, would be very happy to participate in and encourage such work.

Coal Board Research

The National Coal Board announces that Professor H. L. Riley, Professor of Inorganic and Physical Chemistry at the University of Durham, has been appointed director of carbonisation research. Dr. W. Idris Jones is leaving the Powell Duffryn Company to become the Board's Director-General of Research.

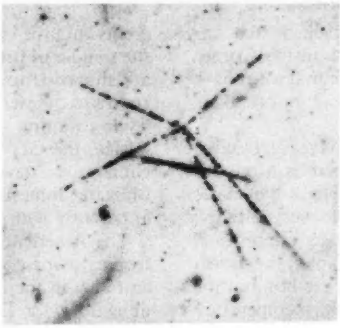
Scientific member of the Coal Board is Sir Charles Ellis.

A.Sc.W. and Social Sciences

A national Social Science Committee of the Association of Scientific Workers was set up at a conference held in London on December 14. This body will be concerned with the status and salaries of social scientists, and the role of the social sciences in community life.

Presiding at the conference was Mr. J. R. Brumwell. Speakers included Professor S. Zuckerman, Dr. G. Wagner, Mr. Denis Chapman and Mr. Roy Innes.

The new committee is the successor to a Social Sciences Committee of individual A.Sc.W. members that has been working in London. This has considered certain salary problems; the uses made of the social sciences during war time and their applications to peace time problems; and has been giving special study to the Clapham Report on the financing of research for the social sciences.



A 'Thorium star' in a photographic emulsion. Photomicrograph of the tracks of α-particles emitted during the radioactive disintegration of thorium. (*Courtesy Kodak Research Laboratories.*)

Social scientists interested can obtain detailed information from the A.Sc.W, at 15 Half Moon Street, Piccadilly, London, W.1.

Cure for Foul-brood

Among the many interesting items in the 36th annual report of the John Innes Horticultural Institution is the story of a successful attempt to treat one kind of bee disease with a sulphonamide drug. Last year a foul-brood attack was noticed on May 23 and the disease organism, *Bacillus larvae*, was diagnosed the same day. Sixteen days later these bees were given soluble sulphapyridine in warm syrup and this was repeated every two or three days. The cure was complete in thirty-five days. After the success of the cure had been established an order came from the Ministry of Agriculture for the destruction of the infected bees. The report leaves the sequel to the Ministry's instructions to the reader's imagination!

A hybrid raspberry is mentioned which gave a yield of 60% above that obtained from Norfolk Giant stock. Trials have been made with dwarf tomatoes, and these lead to the conclusion that the so-called varieties known as *First in the Field*, *Premier* and *Q77* are one and the same variety. Wild tomatoes obtained from the mountains of Peru are being crossed with cultivated varieties in an endeavour to secure greater resistance to frost: the hybrid seedlings are subjected to 2-3° C. below freezing-point in a refrigerator and those that survive are kept for breeding purposes.

World List of Scientific Periodicals

Active preparations are being made for the issue of a third edition of the *World List of Scientific Periodicals*. The last edition of this invaluable reference work, issued in 1934, is now out of print though still in constant demand. Covering the years 1900–1933, it contains upwards of 33,000 journal titles and includes the holdings of some 180 libraries in Great Britain and Ireland. The new edition, which is designed to include all the scientific and technical periodicals that appeared during the period 1900–1947 as well as the holdings of additional libraries, will therefore be considerably larger. Librarians are being asked to co-operate as before by sending particulars of all those journals on their shelves that do not appear in the second edition, or are shown there as having no location in this country, to: The Secretary, World List of Scientific Periodicals, c/o The Zoological Society of London, Regent's Park, London, N.W.8, from whom further information may be obtained.

Night Sky in February

The Moon—Full moon occurs on February 5d 15h 50m, U.T. and new moon on February 21d 02h 00m. The following conjunctions take place;

February

4d 20h	Saturn in conjunction with the moon,	Saturn	4 S.
13d 04h	Jupiter ,,	Jupiter	0·02S.
16d 23h	Venus ,,	Venus	5 N.
20d 02h	Mars ,,	Mars	4 N.
22d 09h	Mercury ,,	Mercury	7 N.

The Planets.—Mercury sets less than 20 minutes after the sun on Feb. 1 and 1h 20m after the sun on Feb. 14, attaining its greatest easterly elongation on Feb. 21. At the end of the month the planet sets 1½ hours after the sun and so is favourably placed for observation during February. Venus is a morning star, rising at 4h 43m, 4h 56m and 5h 02m at the beginning, middle and end of the month respectively. The stellar magnitude of the planet varies from −4 to −3·8 during the month. Mars is still too close to the sun for favourable observation. Jupiter, in the constellation of Libra, rises in the morning hours, at 2h 25m, 1h 41m and 0h 52m at the beginning, middle and end of the month respectively. During February the stellar magnitude of the planet is about −1·6 and its distance from the earth varies from 518 to 477 million miles. Saturn, in the constellation of Cancer, is visible through the greater portion of the night, and sets an hour before sunrise on Feb. 1 and Feb. 28. The stellar magnitude of Saturn during the month varies from 0·0 to 0·2 and its distance from the earth varies between 755 and 770 millions of miles.

The stars of spring will soon be conspicuous and in the chief constellation of this season—Leo Major—there are several interesting objects. The constellation is easily recognised by its resemblance to a sickle, and a line through the first two stars, of the Plough-Alpha and Beta Ursae Majoris—passes through Leo Major. Regulus, the brightest star in the constellation, has been called the 'kingly star' but its brilliance scarcely warrants this title because it is one of the fainter stars of the first magnitude. When the constellations in the zodiac were first named the sun was in this constellation at midsummer, and this gave to the brightest star in Leo its primacy which it has ever since enjoyed. Regulus has a companion of magnitude 8·5 which can be seen through a small telescope.

THE PROGRESS OF SCIENCE—*continued from p. 5.*

that region, and the conclusion was reached that the species has given up its domestic existence in the Crimea and has reverted to the ancestral way of life that must have characterised the cockroach before the comfort of a man-made environment was available.

The Common Cockroach seems to have arrived in England about the time of Elizabeth. There is a reliable reference to its occurrence here in wine cellars that dates back to 1624. In Britain it did not spread very rapidly; Gilbert White, writing in 1790, said it was an unusual insect at Selbourne. This is understandable; the insect comes from a country where the summers are hot and the winters moderate, and the average outdoor temperature of a British winter scarcely favours the spread of the insect.

The German Cockroach has been in Britain a shorter time, and its more recent arrival probably accounts for its patchy distribution. There is one story to the effect that it was introduced (like the cigarette) by soldiers returning from the Crimea, but this seems unlikely; it seems to have been widely established in Britain by about the middle of the nineteenth century. Its European travels are supposed to have started from Russia when the trade routes to the west were opened after the Thirty Years War; while awaiting the next stage on its long hitch-hike from Africa, the German Cockroach colonised Russia, but the climate was never inviting enough to make it give up its obligate domesticity and live out of doors, as happened apparently with the Common Cockroach.

The American and Australian Cockroaches come from tropical Africa, where they occur in buildings and shelters and also in the open, near villages. House-dwelling is not obligatory for these species, though their tropical origin makes itself evident when the insects reach countries with colder climates where they survive only in the protective warmth of hothouses and similarly favourable places. In South America the prevailing temperatures favour these two species as against the Common and German Cockroaches.

INCENTIVES AND THE SOVIET INVENTOR—*continued from p. 12*

they also permit a tax-free allowance up to £400 on such payments, the author would be justified on the facts of the case if he paid a compliment to Soviet generosity on the low level where it applies particularly to the working class. There does seem to be a case for proposing that on this level awards paid by industrial companies in the United Kingdom should be higher, but certainly on the medium level, where true inventions and important technical improvements exert their maximum influence, the net return to the inventor and improver in Western countries is undoubtedly higher. In the chemical industry, for instance, it probably averages between 20% and 25% of the net savings. The merits of patent systems are strongly disputed at the present time and by contrast the Soviet system of awards appears to be much fairer in theory as it removes the element of gamble and the injustices of relative strength existing under conditions of free negotiation between two parties of which the weaker is usually the inventor. But in practice is it doubtful whether it is yet possible to justify the claims that the Soviet award system is working smoothly and with sufficient momentum to fulfil the perpetual need for inspiring 'creative thought'. Incentive, however rough, is essential to progress and although Emerson once said: "The reward of a thing well done is to have done it"—it is also currently true and will remain true for some time to come that "Money makes imagination move." Or to be more exact, anticipation of wealth makes imagination move.

POWER PLANTS FOR HIGH-SPEED FLIGHT—*continued from p. 17*

It will probably employ a very low compression ratio, and have an auxiliary athodyd placed in the jet, so that the exhaust gases of the turbine are 'reheated' in this duct.

The efficiency of such an engine is likely to be smaller than that of normal gas-turbine engines, but its weight will be considerably reduced in relation to its thrust. The addition of a duct or second combustion chamber in the exhaust gases is sometimes called 'after-burning'.

But whatever the type of power plant used, considerable research will have to be conducted before supersonic flight becomes a really practical proposition. The achievement of supersonic speeds is round the corner; but the realisation of supersonic *flight* may well be a long way off.

ENIAC, ASCC and ACE—*continued from p. 27*

all ready punched and catalogued; for any particular problem, some of these sets will be used, possibly linked together by special instructions.

The speed of each individual operation with ACE will apparently not be very much greater than that of ENIAC (the limitations on the speed of electronic responses see to that), but with the saving of time in setting up, its effective speed will be very much higher, while its greater flexibility and capacity will ensure that it can conveniently and rapidly solve virtually any problem of practical mathematics which man can formulate.

When ACE is in action the spirit of Babbage will at last be able to rest in peace.

REFERENCES

Full details of ASCC are given in *A Manual of Operation for the Automatic Sequence Controlled Calculator*, written by the staff of Harvard's Computation Laboratory (1946, Harvard University Press, $10; published in Britain by Oxford University Press, 56*s*.) This book provides a very fine bibliography of computational methods.

Readers requiring more information about ENIAC are referred to the article in *Nature* (October 12, 1946; p. 500) by Professor D. R. Hartree.

The information about ACE is taken from the DSIR statement issued on November 6, 1946.

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